CREATING HEALTHIER METROPOLITAN ECOSYSTEMS: HONEY BEE HABITAT AS A GUIDELINE FOR CHANGE

BY

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THESIS

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ABSTRACT

This thesis explores the history, needs and habitat of the western honey bee (*Apis mellifera*), producing a set of guidelines that integrates bee habitat with human habitat to ultimately create more sustainable, healthier, urban environments. Habitats, both natural and metropolitan, across the globe have been altered by human development and are no longer able to function in healthy and sustainable ways. The interconnectedness of ecological systems creates opportunities for the system to adjust itself, but also means that if one aspect of the system is harmed, destroyed or altered the effect will ripple outward in unexpected ways. Honey bee numbers have been declining for many years but since 2006 the patterns have changed; whole hive systems have collapsed. This ripple in the ecological system is of particular interest to agriculture and to 1/3 of the world's food supply. Other concerns resulting from honey bee decline, economically are many, environmentally they are yet indeterminable.

This work presents one possible model to improve ecological systems within metropolitan areas. Its purpose is to create connections and links between traditional urban planting design and natural systems that will support sustainable honey bee populations while also supporting

sustainable, healthier, multifunctional neighborhoods for humans. It is my hope that by creating an efficient method to relay this ecological information more quality habitat areas may be integrated into the fabric of our cities.

CONTENTS

CHAPTER 1

OVERVIEW

The human heart and the environment
are inseparably linked together.
If you think only of yourself,
ultimately you will lose.

--H.H. The Dalai Lama,
The Heart of Compassion
(Dondrub, 2002)

Honey bees (*Apis mellifera*) are valuable pollinators of commercial food crops in North America, Europe and western Asia (Naug, 2009; van Englesdorp and Meixner, 2010). The value of their pollination services in terms of higher yields in the U.S. ranges from $14 to $18 billion (Stankus, 2007). It is estimated that 1/3 of our diet benefits directly or indirectly from pollination. While humans could still survive without honey bees, their diet would be severely restricted because these are the foods that provide our diet diversity, flavor, and nutrition (USDA, 2013). Those crops mostly dependent on honey bees are: almonds, apples, cherries, blueberries, broccoli, cantaloupe, carrots, citrus, cranberries, cucumbers, kiwi fruits, pumpkins, squash, and watermelon (Rodreiguez-Saona 2007; Walters and Taylor 2006). To a lesser degree honey bee services are employed for strawberries, peppers, peaches, plums, and pears (Stankus, 2007).

In 2006, beekeepers reported losses of 30-60% of their bee colonies. This phenomenon was named “colony collapse disorder” (CCD). No single factor causes CCD. It is likely caused by multiple stress factors including: lack of food habitat due to production agriculture monocultures and land development, pesticides used in food production, pathogens, and parasites. CCD poses the potential for serious losses of both pollinators and commercial crops (USDA, 2013). Annual colony losses from 2006-2011 averaged about 33 percent each year (USDA, 2013; vanEngelsdorp et al., 2012).

Human land use and development have caused major disruptions in urban and rural ecological systems and they result in two potential causal factors of CCD: habitat loss and toxic chemicals. Agricultural land now covers 80-90% of the Midwest, creating a virtual resource desert for bees (Kremen et al.2007; Winfree et al., 2008); as does urban land which is often devoid of all vegetation or a vegetative monoculture, providing little habitat for honeybees. In addition, both agricultural lands and urban lands often receive large amounts of pesticides (Delaplane, 2002). To improve these habitats and the human condition within them, it is vital to understand urban and rural ecosystems, their functions, and their causal relationships.

This study investigated the resource requirements for two species - honey bees and humans (*Homo sapiens*). The objective was to develop guidelines that incorporate human needs with honey bee needs to influence urban ecosystems in positive ways that aid in the creation and design of more sustainable, healthier urban environments.

This study took existing scientific research and developed creative design guidelines to be used by private home owners as well as by professional landscape architects and urban planners. The end product integrates best management practices (BMPs) for human development with BMPs for bees. It is hoped that the approach will not only benefit bees and humans but also the larger ecosystem as a whole.

Historically sustainability and aesthetic expression have often been diametrically opposed. Design attempts to mitigate disturbance often succeed in the creation of beautiful, distinctive and natural looking features that fail because they play no role in ecosystem function. These design failures result in superficial embellishment of the landscape (Spirn, 1984), meant to “create” nature rather than design with nature (McHarg, 1969).

Bridges between form and function of landscape must be established to create lasting environmentally dynamic solutions. There are many examples where design has overcome the form-versus-function dichotomy in which optimal form supports optimal function. Patchett and Wilhelm (2008), of Conservation Design Forum, give a thought provoking scenario of aircraft design as an example:

> “What is the controlling factor in aircraft design – performance and safety, or just aesthetics? Is not the performance of the land on which we live and depend just as important as the performance of a transportation vehicle? A safe, high-performance airplane is inherently attractive. So also would be a building and landscape well integrated into the place.”

Builders of North American cities have not chosen this balanced approach in design. Municipalities have become sink holes for carbon, catalysts for flooding and downstream pollution issues, and heat islands that generate rising temperatures in greater and greater expanses as the cities continue to sprawl (McHarg, 1969; Odum, 1993). Environmentalists, biologists, designers and others are all working to alleviate if not eliminate these problems; however, connections between these disciplines must be stronger.

No one discipline will be able to solve these issues in a vacuum. An ecosystem is a multilayered, complex system; the approach to design must be just as diverse and dynamic (Odum, 1993). Connections and interconnections among disciplines must be established to provide a web of information, ideas and solutions to solve these issues, ultimately creating high performance, safe, and aesthetic cities (Corner, 2006). The ideals of design and science can be integrated, combining good design with ecological concepts to create symbiotic relationships. From initial site analysis through the final design stage, designers such as

Chris Reed (2009, personal communication), seek out experts in a variety of fields that have the knowledge to deal specifically with on-site issues.

People today may be more disconnected from nature than at any other time in history. Modern lifestyles have isolated us from the natural environment, with humans spending more than 90% of their lives in buildings (Evans and Mccoy, 1998). Our typical connections outside of buildings are with our own processed environment of roads, cars, and industry; we rarely, if ever, experience a connection with the natural world we are hoping to save (Folisi, 2009). A name for this disconnect, "nature deficit disorder," was coined by Louv (2005). It leads to the question that if most of society has never been exposed to nature, then how can we depend on society to save nature?

The current honey bee problem offered an opportunity to design an urban model that reconnects with nature. It provides an alternative that individuals and communities may adopt to improve ecological systems in the places where they reside. By combining a knowledge of natural processes with best management practices for urban development (both new and retrofit practices), design guidelines have been established. This guide integrates several aspects of the honey bee's life with those of the urban resident in an attempt to create a more dynamic, healthier environment for both. The guide is an attempt to create an efficient method that integrates ecological information with the urban fabric. This integration establishes the opportunity for scientists, practitioners, and ordinary citizens to test the assumption that by creating urban space for sustainable honey bee populations to thrive, human neighborhoods will also become sustainable, healthier, and multifunctional.

Figure 1. The Idealized City
The image represents a park space that is beneficial to the human residents who visit as well as to the pollinators. Based on plant lists and blooming times from the Missouri Botanical Garden. Missouri Botanical Gardens, 2016

CHAPTER 2

HUMAN EFFECTS ON ECOLOGY

Only when the last tree has died
and the last river been poisoned
and the last fish been caught
will we realize we cannot eat money.

--Cree Indian Proverb

Ecological Systems

The natural world is made up of territories and sheds (water and air) that combine to create interconnected systems. All abiotic and biotic components within a particular water- or airshed are part of that specific local ecological system. Local systems interact, forming regional systems, and regional systems interact, ultimately forming global systems. No aspect of the planet operates completely independently. System diversity and interconnectedness results in redundancy and creates resilient systems. However, if system diversity is reduced or destroyed the effect can ripple through the system in unexpected ways (Davis, 2009). One example of this would be the introduction of the multiflora rose into Missouri and Illinois for soil control and habitat support (Missouri Department of Conservation, 2010). As late as the 1960's this plant was distributed to farmers but the species became highly invasive in pastures, agricultural land and natural communities often out competing native plants preferred by the fauna and reducing native diversity (Missouri Department of Conservation, 2010). What was meant to aid an ailing ecosystem actually contributed to its damage.

Ecosystems are not just "native pristine" communities they also include human-dominated agricultural lands, towns and cities (Figure 2). In fact, humans are now an integral component of all ecosystems on Earth. These systems may function very differently than they did prior

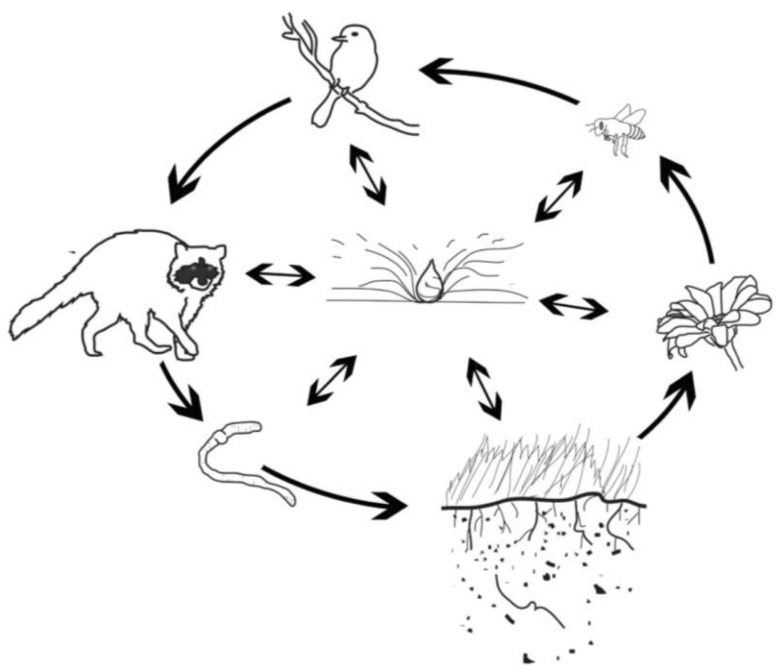


Figure 2. Simple Natural Ecosystem. The natural world is filled with systems. One component utilizes another in order to exist. This over simplified image represents a food chain with the interaction of water. Here one organism feeds on another to complete the chain.

to human settlement but the systems still exist and may have adapted to function under the influence of man. Henry David Thoreau's woods in Concord, Massachusetts are a prime illustration of how one system has been affected. Between 1852 and 1858 Thoreau recorded statistics for over 500 flowering plant species each year (Thoreau, 1999). Other botanists have updated his studies in the years 1878, 1888-1902, 1963-1993, and 2003-2006 (Miller-Rushing and Primack, 2008; Allison, 2012). Current temperatures in the area have increased on average 2.4 degrees Celsius and plants are flowering on average 7 days earlier than in 1852. Those plants that adapted to temperature change by shifting their flowering times have been the most successful in maintaining populations. Those plants that failed to change flowering times with temperature have had the most significant declines (Allison, 2012). An awareness of systems ecology is vital as humans continue to change their surroundings in both deliberate and inadvertent ways.

Nature Versus Urban Design

In many cultures throughout history nature has been deemed wild, associated with danger and even evil. Any part of the natural world that was not tamed, sculpted, and controlled in the western world has been deemed uncivilized from pets to gardens. The city was a *tabula rasa* to create and fashion as desired. Civilization and nature have been understood to be on opposing ends of the spectrum. Cities are where people live and the regions beyond are where nature lives (Hough, 2004).

Urban sprawl is bringing civilization and nature ever closer, suburbanizing the wildlands and allowing nature to incorporate itself into the city fabric (Birch and Wachter, 2008). After reviewing human population growth over the last 1,200 years Jon Rodiek (2008), expert in human and wildlife habitats, has drawn the conclusion that urban expansion today is just "the latest stage in the continuing evolution of our human population".

Many urban geographers, planners and designers have written about this issue. Lisa Benton-Short, Associate Professor of Geography at George Washington University in Washington D.C. with her husband John Rennie Short, Professor of Geography and Public Policy at the University of Maryland, Baltimore County (Benton-Short and Short, 2008), Michael Hough (2004, 1984), Landscape Architect, and Marina

Alberti (2008), Professor of Urban and Environmental Planning at the University of Washington all have written extensively on the issues and opportunities that develop when cities focus on being part of an ecological system instead of fighting against it. The Shorts (2008) note, in their book *Cities and Nature,* statistics about the United States Capital's struggle with green space loss. Due to rapid growth in Washington D.C. the metropolitan area lost 50% of its green space between the years of 1986 and 2000. They also mention that this sprawl and development isn't just reducing human quality of life. It has increased the risk of flooding, air pollution, ecosystem fragmentation and reduced diversity of species living in the area. The results are not unique to the District of Columbia. Across the United States, census statistics indicate that the size of the of the American house has increased from an average of 1,170 square feet in 1955 to 2,266 square feet in 2000, even while the size of the American household has decreased from an average of 3.4 to 2.6 members (Hester, 2006). Americans are taking up more and more built space, and leaving less space for other species.

In these urbanized environments "[p]rotecting natural landscapes… is for the most part, an afterthought of any proposed master plan" (Rodiek, 2008). If humans are to create more sustainable spaces this has to change. Jon Rodiek (2009) frames this type of design as having "Ecological Services" in mind. Historically developers have focused on the economic value of bricks and mortar within developments but ecosystems which provide critical natural services for our survival have yet to be assigned an economic value.

> "Among these sources are clean air and water, reduced soil erosion and sedimentation in waterways, the production of topsoil, the sequestering of carbon to mitigate climate change and moderate weather, the reduction of flood and droughts and the preservation of habitats of plants and animals. There are, in addition to these less, tangible service benefits such as aesthetic beauty and cultural and recreational values" (Rodiek, 2009).

It is argued that the current social/political state of human development cannot support the cost of sustainability and that the economic inertia of capitalism will over-ride any "health of the ecosystem" (Rodiek, 2009). There are others who argue that capitalism will save the system such as Dan Dagget (2005), self proclaimed "conservative environmentalist." In a speech at Knox College on September 27, 2010 he relayed images and stories of what ranchers have been able to accomplish in Nevada and Arizona to reestablish plant life and to manage nature while earning a living. The actual political side of the fence doesn't matter. Stopping the narcissistic pillaging and exploitation of resources and finding a balance where the land is able to support life is the hurdle that must be faced. Developing even small steps to bridge the gap that exists between consumerists and environmentalists will make a difference.

Consequences of Development Without Nature

Urban problems are not new. These issues have been documented repeatedly. Emperor Frederick II Hohenstaufen in 1231 created laws imposing fines in an attempt to clean the air of Sicily (Benton-Short and Short, 2008). In today's civilized societies new type of air pollution have developed and new laws have been made to control them. Many additional issues have also arisen. In their quest to manipulate the environment humans have eliminated conditions that are optimal for many plant and animal species. Results such as proximity to controlled flooding, erosion, insect, and weed control have occurred, but the conditions that are created inadvertently result in consequences that are often worse than the original problem. As an example, flood control, levees and dams have allowed human development in natural, historic flood plains. However, during low probability flood events loss of property and life exceed the benefits of the flood control. Another example is the use of pesticides to control weeds and insects. Although the proximate results are good the ultimate results are negative increasing toxicity levels in water and food and resistance in the pest they were originally supposed to control. Human control of the environment has resulted in habitat destruction, fragmentation and inadvertent contamination, all of which are contributing factors in the decline of animal species. Honey Bee Colony Collapse Disorder, discussed in Chapter six, is another example of an inadvertent effect of human disruption of living systems.

The human's complete disconnect with the natural world is one of the earth's most pressing problems. According to Patchett and Wilhelm (2008), "… [w]e have lost touch with the importance of a sustainable cultural relationship with land and water, [western culture has] largely forsaken the human relationship with the natural environment and therefore threatened our own very well being." Patchett and Wilhelm (2001) also believe that traditional site planning and development, from corporate and institutional campuses to residential subdivisions, epitomize the disconnection. Randolph Hester (2006), in *Designing for Ecological Democracy*, acknowledged a loss of connection which he coined as “rootlessness”. He believes the five most essential American values are “mobility, affluence, standardization, technology, and specialization.” These values lead to “rootlessness” and are hurdles to changing the philosophy of specialized single purpose landscapes to a philosophy of general multipurpose landscapes. General multipurpose landscape design based on sound science can meet the desires and needs of humans, making a reconnection with the natural world, and in turn supporting bees and other wildlife (Hostetler and Drake, 2009).

Finding Balance

One option for beginning a process of change is creating what Hester (2006) calls “adaptable cities.” These are areas designed “so that many environments serve more than one purpose, are connected, are suitable for new uses, are flexible but not entirely open-ended, and are suggest[ive] rather than dictatorial” (Hester, 2006). In a similar vein, Patchett and Wilhelm (2001) believe the design of environments where humans and other organisms interact, where actions create reactions, and where the future is built on an understanding and appreciation of the past requires that good design and healthy environment are synonymous. Regardless of scale, the design of sustainable environments means facilitating human purposes in concert with natural processes. This thesis makes the assumption that a design that meets the needs of honey bees will also meet the needs of other pollinators and many other animals. According to Hester (2006) “Nature must be big enough and interconnected to provide wildlife habitat and linear recreation but it must be small enough to be close at hand without diminishing density.” Carefully crafted spaces that are sound economic developments and that are held to the highest level of environmental stewardship not only can be accomplished but are becoming an inseparable reality (Patchett and Wilhelm, 2001). Ecologically sustainable solutions to our urban problems in many cases mimic natural systems or natural processes. For example, green roofs and walls, porous pavement, bioswales, and buffer strips all provide ecological functions that can sequester carbon, alter hydrology, filter contaminated water and, at the same time provide habitat for multiple species, including the honey bee. Through such scenarios a practical model to improve the ecosystem for a diverse set of species will be developed.

Another reason to adopt a more ecological design approach is the human preference for natural landscapes. In 1989 investigators asked university landscape architecture students to record environmentally aesthetic experiences in their class diaries (Thayer, 1994). The assumption was that environmental aesthetic experience would be associated with large scale more “pristine” experiences. The results, however, were unexpected. Environmental aesthetic experiences often happened in a familiar place and were “a result of interactions with natural objects…” (Thayer, 1994). Students almost unanimously stated that there was an improvement in their mood subsequent to this natural aesthetic experience. Investigators concluded that opportunities need to be made available for people in their home environments to spend time in natural settings so they gain the same type of benefits as the students in the study (Thayer, 1994).

Besides the basic needs for life (food, water and shelter), humans also need interaction with other living things (Fromm, 1994). This has been known for hundreds of years. The question arises, if this knowledge has existed for so long, why is it not being more widely utilized? One reason may be that the modern human population has not recognized the problem nor cared about the impacts unless those impacts directly affected their lives in a personal and obvious way (Orr, 1993). As we reach a time when resources have become scarcer and we see the effects of excessive resource use on the environment, the importance of nature in our everyday life is made more clear (Wilson, 1984). Thus, the timing of this project has advantages. A second reason may be that much of the science and research available is imbedded within the scientific community or buried under a morass of the other information in this “information age”. Guidance on plant communities in urban areas with consideration of climate change and other ecological factors remains limited even in the scientific community (Hunter, 2011). Professionals must find the time to gather and share their data so that designs may be better able to meet the needs of living systems.

CHAPTER 3

HISTORY OF HUMAN INTERACTION WITH THE HONEY BEE

Such is their toil and such their busy pains
As exercise the bees in flowery plains
When winter past and summer scarce begun,
Invites them forth to labour in the sun.

-- Virgil, Georgics

MAN AND BEE RELATIONSHIP

In biological systems symbiotic relationships develop and species co-exist, adapting to each other naturally over time. This is partly true of the relationship between the honey bee and humans (Figure 3). The difference is humans have played a substantial role in controlling the evolution of the honey bee. Human management of hives has changed due to in-depth study and analysis; thus human, behavior has adapted

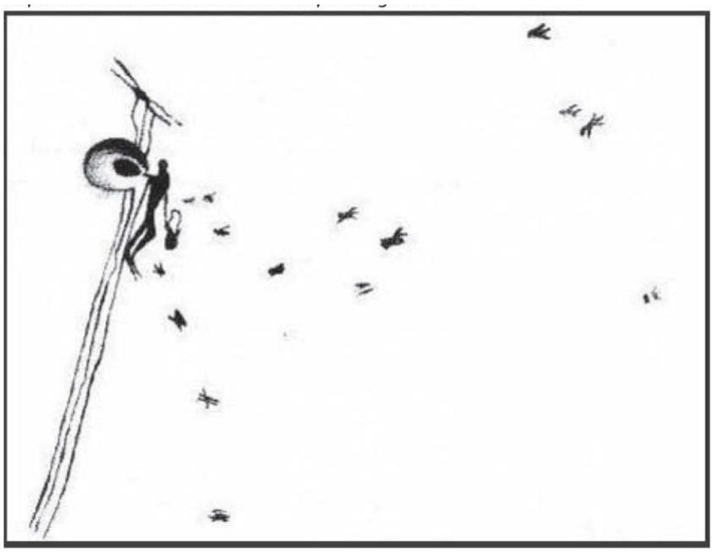


Figure 3. Man of Bicorp 7,000 BCE. Discovered in the early 1900s in Valencia, Spain in the Cueve de la Arana. The painting speaks of a long fascination with honey. http://www.mdbee.com/articles/cavepainting.html

but compared to the honey bee this adaptation has been relatively small. From differing perspectives the human role in this relationship has been deemed parasitic, economic-exploitative or caregiver. According to the views of Michael Pollan (2001) in his popular book *The Botany of Desire*, just as natural selection makes the flower produce sweet nectar to draw in the bees which then spread pollen, it could be argued that the honey bee makes honey to attract humans, who then kill pests to protect the honey bee. The exact definition of this relationship and how each side has affected the other does not have to be agreed upon, but the long history between the two species cannot be denied.

Ancient Art and Myth

The first record of *Homo sapiens* organizing to steal honey dates to about 7000 BCE. The cave painting commonly referred to as *Man of Bicorp* was discovered in Valencia, Spain in the Cueve de la Arana, the Cave of the Spider (Benjamin, 2009). The image is of bees flying around a person on a rope-like ladder with his/her hand in a hive, the other hand holding a bucket.

Figure 4. Tomb of Pabasa, Egypt *2,400 BCE.*
Egyptians built horizontal hives made of unbaked clay or mud stacked one on top of another. *www.bee-hexagon.net/en/creativeexpression.htm*

Documentation indicates that the Egyptians were the first culture to actively keep bees for honey. In 2,400 BCE they created horizontal hives made of unbaked clay or mud stacked one on top of another (Berenbaum, 1995). The ancient Egyptians also appear to be the first to record a mythology of bees. Throughout Egypt bees were considered sacred, growing from the tears of Ra. This led the King of Lower Egypt to create a symbol that was a bee hieroglyph (Readericker-Henderson, 2009).

Myths about the honey bee prevail across the world. In India Vishnu Sahasranama, the supreme God for Vaishnavas and one of the main forms of God in other Hindu traditions was said to be honey-born.

There is also the Hindu Goddess of the black bees, Bhramari Devi. Bhramari Devi is believed to reside inside the heart chakra and to emit the buzzing sound of bees, which is replicated in many Vedic mantras. Her story is written about 2000 BCE in the Srimad Devi Bagavatam: Book 10 Chapter 13. In the story the Goddess protected the wives of the nature spirits by transforming into a large bee and creating a swarm of bees which emerged out of her hands covering the world in darkness and stinging a demon and his followers to death (Bhramari Devi, 2009).

Figure 5. Bhramari Devi – Hindu Goddess of the Black Bees *2,000 BCE.* The Goddess turned into a large bee and called forth a swarm of bees from her hands to defend the wives of the nature spirits from a demon. *http://www.saisathyasai.com/india_hinduism_gods_goddesses/bhramari-devi-goddess-of-bees.html*

The oldest American beekeeping artifacts, dated 300 BCE, are of the Mayan God, Ah Mucan Cab, the God of honey (Crane, 1999). The Mayans so honored honey and honey wine that they had festivals

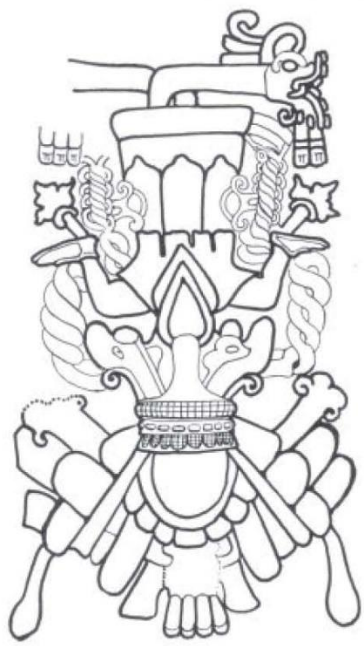


Figure 6. Ah Mucan Cab – Mayan God of Honey
300 BCE.
The Maya so honored honey and honey wine, they had festivals dedicated to the god of honey, Ah Mucan Cab.
www.authenticmaya .com/maya_agriculture.htm

dedicated to the God of honey (Authentic Maya website, 2009). The bee god is represented in a gateway in the most picturesque building in Tulam, the largest most impressive Maya city on the east coast of the Yucatan and in the palace of Sayil built in 800AD (von Hagen, 1961). Across the ancient globe, wherever there were honey bees and people, bees were held as sacred and honey as a food from the gods.

Greece also regarded the honey bee with great mystery and mysticism as conveyed through many myths and stories. One such story has to do with Apollo, the god of light, healing, prophecy and truth. The Homeric Hymn to Hermes originally written in 600 BCE, tells the story

Figure 7. Thriai – Bee Goddess Greece *600 BCE.*
Three bee goddess, named the Thriai cared for and taught Apollo during his childhood.
http://en. wikipedia.org/wiki/ Bee_(mythology)

of Apollo and his half-brother Hermes; their rivalry and reconciliation. One section mentions Apollo's upbringing and his training. His childhood teachers were the Thriai, three maidens possessing divine power (Hyde, 1999). It is uncertain whether the poet intended the three women to be changed completely into bees or winged women with bee bodies, but the association of honey bees and mysticism is evident (Allen et al., 1963). These bee goddesses fed Apollo the food of the God's, honey, and imparted the gift of prophecy on him (Hyde, 1999).

The stories of the magic and wonder of the honey bee hive seem to appear in every culture where honey bees were established. Their dedication to community, other worldly sense of communications, self-sacrifice and production capabilities leave humans in reverence of these tiny creatures.

Figure 8. The Coinage of Ephesus Greece *385 BCE.*
These images are dominated by the cult of Artemis. The bee, a fertility symbol, regularly found on copies of her money and statues, is a reminder of her universal motherhood.
http://learn.mq.edu.au/webct/RelativeResourceManager/15043963001/Public%20Files/about.htm

WESTERN SYMBOLISM

Due to their perceived work ethic, community involvement and self-sacrifice the honey bee has become the focus of cultural iconography and propaganda. For example, the honey bee has appeared on many types of currency. One such example are the Coins of Ephesus honoring Artemis from ancient Greece. These coins were minted in 385 BCE with, one side featuring Artemis and the other picturing the honey bee. Artemis was the goddess of the wilderness, the hunt, wild animals, and fertility. She was daughter of Zeus and twin to Apollo (Fischer-

Hansen, Paulsen and Paulsen, 2009). The honey bees were found on many of Artemis' statues and buildings as a reminder of her universal motherhood (Ephesus Coinage Website, 2005).

Figure 9. Bee Hives on Early United States Dollars *1779.*
On a 45-dollar bill is a representation of an apiary in which two beehives are visible. The motto – SIC FLORET REPUBLICA – "Thus flourishes the Republic" conveys the simple lesson that by industry and frugality the Republic would prosper.
http://revolutionarywararchives.org/continentalmoney.html

Bee hives were also printed on early United States 45-dollar bills. Issued on January 14th 1779, the Philadelphia Constitutional Congress adopted the new bill with an image representing an apiary in which two beehives are visible and bees can be seen flying about (Crane, 1999). The motto on the bills are – SIC FLORET REPUBLICA – "Thus flourishes the Republic." This conveys the simple lesson that by industry and frugality the Republic would prosper (Revolutionary War Archives Web Site, 2009).

Just as throughout ancient times when bees were honored and revered, modern cultures have held up the honey bee as an icon to be emulated.

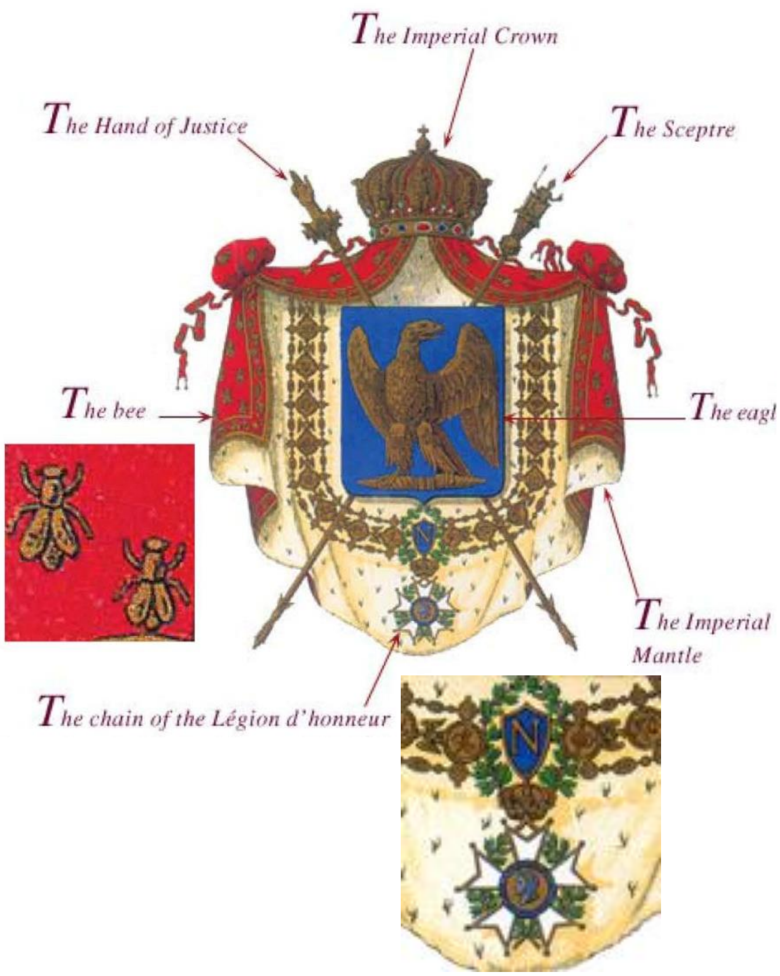


Figure 10. Napoleon's Coat of Arms France *1804.* Symbol of immortality and resurrection, the bee was chosen to link the new dynasty with the very origins of France. *http://www. Napoleon.org*

Upon his coronation in 1804 Napoleon I surrounded himself with bee symbolism. His velvet robe embroidered with imperial golden bees in a brazen attempt to replicate the coronation of Emperor Charlemagne (Benjamin, 2009). He knew the bee was a symbol of immortality and resurrection, so the bee was chosen to link the new dynasty to the very origins of France; they were considered as the oldest emblems of the sovereigns of France. He also chose to have bees on the mantle of his coat of arms, which also integrated the Chain of the Legion d'honneur. The Chain was a decoration created in 1802 for military and civil services that incorporated bees and was reserved for the emperor,

Figure 11. City of Manchester Coat of Arms – England *1842.*
Symbols of the City of Manchester's industrious nature, 7 bees adorn the top of the Coat of Arms.
http://www.manchester.gov.uk

prince of the imperial family and grand dignitaries (Napoleon. Org Fondation Napoleon history website, 2016). Bees also adorn the city of Manchester England's coat of arms granted to the borough in 1842, symbolizing Manchester's industrious nature (Manchester, 2012). This symbolism is carried through many landmarks; one example is the landing just outside the Great Hall in Manchester City Hall, which held its opening ceremony in September, 1877 (Cunningham and Waterhouse, 1992). The landing is named “the Bees” because of the elaborate pattern of bees on the mosaic floor (Manchester, 2012).

SCIENCE AND INDUSTRY

It was not until 1500 that western apiary science as it is known today began. Luis Mendez de Tornes recorded the life cycle of the principled bee and made the discovery that *she* is female, thus recognizing her as the queen (Benjamin and McCallum, 2009). English scientists studied honey bees in detail throughout the early to mid 1600s. Drones were identified as male by Charles Butler in 1609. Twenty-eight years later Richard Remnant determined that all worker bees are female (Seeley, 2010).

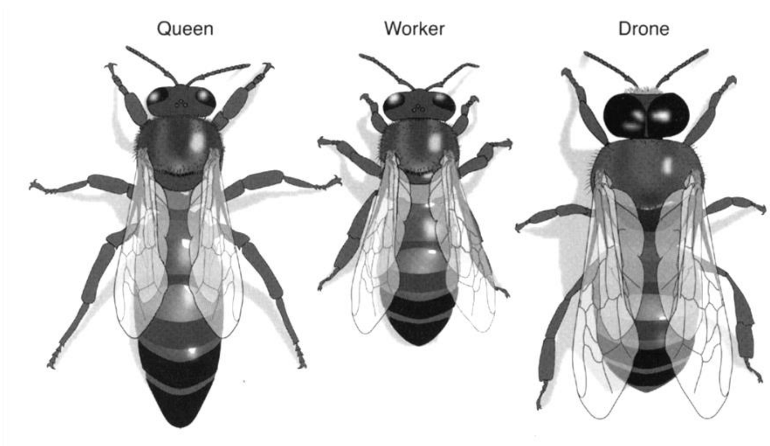


Figure 12. Three Types of Adult Honey bees:
Female Queen
Discovered: *1500*
Male Drone
Discovered: *1609*
Female Worker
Discovered: *1637*
(Seeley; 2010).

Several hives were developed that allowed the beekeeper to take honey without destroying the hive (Figure 13). Lorenzo Langstroth, a

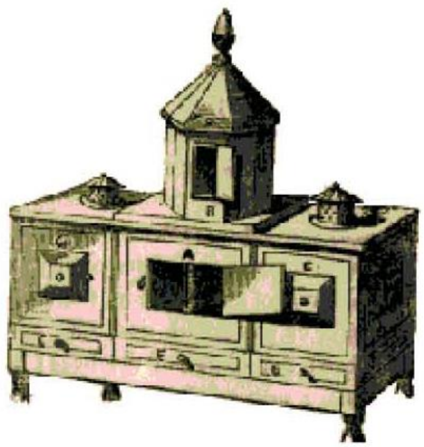
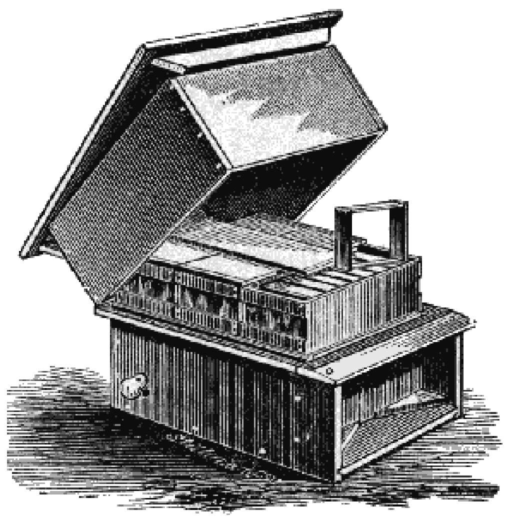


Figure 13. The "Nutt Collateral Hive" Developed *1800.*
Some skeps and box hives from the 1800s make use of supers and separate honey compartments that allowed the beekeeper to remove honey without destroying the colony. The "Nutt Collateral Hive" is one example.
http://www.outdoorplace .org/beekeeping/history1.htm



The original Langstroth hive.

Figure 14. Lorenzo Langstroth's Bee Hive *1851.*
This hive was the first to incorporate "bee space". This is the space that a colony needs between the slats and within the overall hive. This is the model for all modern day hives.
http://www.outdoorplace .org/beekeeping/history1.htm

beekeeper in Philadelphia created several different types of skeps and hives to cut back on waste and vulnerability. In October 1851 he became the first to be credited with the application of the concept that has been referred to as "bee space". Beekeeping up to this point was laborious and extremely wasteful. For the beekeeper to harvest the honey in the fall the hive had to be at least partially destroyed. This practice would leave the bees vulnerable to the cold and to predators.

“Bee space – the 0.3-inch-wide aisle bees leave between their combs- was Langstroth’s epiphany” (Jacobsen and Rowan, 2008). No matter the shape or size of the hive, honey bees keep this spacing rigidly. The Langstroth Hive, which is still being used with only small variations, was envisioned like a filing cabinet, “each hanging file, or frame, being exactly wide enough for a two-sided sheet of honeycomb and exactly one bee space apart from the next frame and from the surrounding box” (Jacobsen and Rowan, 2008). Within a decade Langstroth’s hives were in use across the nation and within 20 years they were being used world-wide (Jacobsen and Rowan, 2008).

Historically the means of communication among the bees was recognized by many astute apiarists, but the scientific study of this communication was not done in earnest until 1920. This is when Karl von Frisch began his complex and lengthy series of experiments (Readicker-Henderson, 2009). His findings were not solidified and published in book form until 1967 (Seeley, 1995). In the first edition of C. P. Dadant's *First Lessons in Beekeeping*, a book written specifically "for colleges and schools teaching short courses on bee culture" (Dadant, 1919), there is no mention of bees communicating with each other. Dadant is held today as one of the founding fathers of the beekeeping industry (Flottum, 2010) and the book is extremely detailed in bee biology and hive requirements but the absence of this information on how the bees communicate would suggest that the

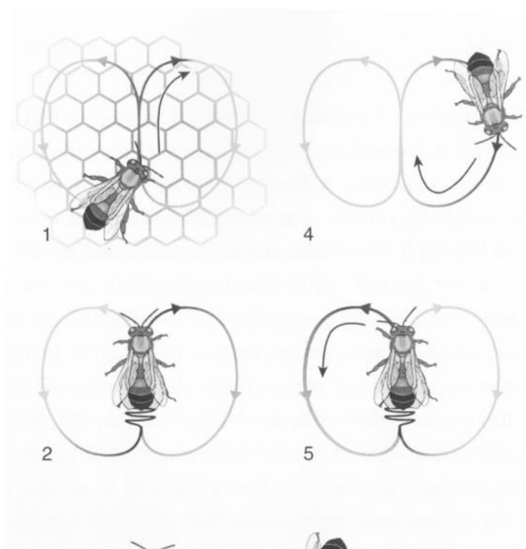


Figure 15. Dance Language First Published *1967.*
Karl von Frisch studied bee behaviors for 47 years before publishing his book deciphering dance language performed by honey bees. This image shows two full rotations of a dance (*Seeley, 2010).*

knowledge of a bee language prior to von Frisch's first experiments was anecdotal. In 1973 Karl von Frisch was awarded the Nobel Prize in Physiology for his work on the honey bees dance language (von Frisch, 2012).

CHAPTER 4

UNITED STATES HONEY BEE TIMELINE

Wheresoe'er they move, before them
Swarms the stinging fly, the Ahmo,
Swarms the bee, the honey-maker;
Wheresoe'er they tread, beneath them
Springs a flower unknown among us,
Springs the White-man's Foot in blossom.

-- Henry Wadsworth Longfellow, Hiawatha

FIRST ARRIVAL

Honey bees are not native to North America; the indigenous people called them the “white man’s fly” because where these “flies” were seen colonists soon followed (Crane, 1999). On December 5, 1621 the Virginia Company in London sent a letter to the Governor and Council in Virginia saying that the ship Discovery had left England in November carrying “divers sorte of seed, and fruit trees… and beehives” (Benjamin and McCallum, 2009). Four arduous months later, the western honey bee landed in the New World. From Jamestown the honey bees multiplied and spread throughout Virginia, even though it was another 16 years, 1637, before the next shipment made it to North America (Benjamin and McCallum, 2009). Once the bees were well established in Virginia they began to spread. By 1644 the first honey bee was recorded in Connecticut, then New York in 1670, Alabama in 1773, and by 1800 they were recorded west of the Mississippi. Fifty-three years later, 1853, the first feral honey bee hive was recorded in California; at that point honey bees reached from coast to coast.

As the nation developed and grew, hives also grew in number and both domestic and feral hives thrived in this new land. This human development converted many natural lands to built landscapes. Human expansion cleared away natural areas and reduced the natural pollen- and nectar-gathering habitat used by bees. This also left farmers without local pollinators because the destruction of the natural territory, particularly the wooded areas, decimated habitat for wild bees, thus forcing them to move to less developed areas. The first occurrence of bee rental for pollination purposes was documented in New Jersey during 1909. The automobile made long distance transportation of hives possible so pollination could continue in croplands where local hives and full-season nectar flow were absent (Horn, 2005).

War and the Bees

Wars have been particularly profitable for beekeepers (Horn, 2005). During World War I the prices for honey and bees-wax skyrocketed. Due to sugar shortages honey was a favorite sweetener within the United States, but it was also being exported to be given to the troops in the trenches for energy and medicinal purposes. Prewar prices have been estimated at 5 cents a pound but during the war it reached 20-25 cents a pound. During the height of World War I the United States exported 5-10 million pounds of honey to Germany and other warring nations (Horn, 2005). Beeswax had hundreds of uses during the war: waterproofing canvas tents, belts, and metal bullet casings, to mention just a few. The applications of beeswax were similar during World War II although paraffin was in use, in some instances the paraffin would mildew whereas beeswax would not. There was an additional use for bees wax during this war; airplanes that were waxed could save gallons of valuable fuel. Beekeepers were exempt from rationing of wood, sugar, and metal because the keeping of bees was viewed as a patriotic activity and the need for honey and wax was so great (Horn, 2005).

THE DECLINE

There were 6 million colonies recorded in the United States in 1944, when the honey bee population reached its highest numbers. This after-war boon was not to last; by 1980, there were just 3 million colonies remaining. This slow decline had to do with a few viruses, mites and beekeepers retiring. Seven years later, in Wisconsin, apiaries were hit hard by a new group of tiny mites named *Varroa destructor*. These mites have suckers on their feet and sharp chelicerae, fang-like mouthparts, that spread various diseases. The *Varroa* mites spread rapidly by 1994 98% of wild honey bee populations had been wiped out by the mites. Beekeepers were beginning to recover and adapt to these destructive mites when the next devastating blow to bees and beekeepers hit the United States in November 2006. This new devastating phenomenon, called Colony Collapse Disorder (CCD), was first officially reported in the United States in an area just outside Tampa, Florida. Just two years later, in 2008, only 2.4 million honey bee colonies remained in the United States (Schacker, 2008). CCD will be discussed in further depth in Chapter Six.

There have been profound changes throughout the history of the honey bee and people; the existence of both species has been irrevocably intertwined. It is possible that both species could survive independent of the other. However, the condition of each species would be drastically changed. The honey bee without its guardian human would succumb to disease and environmental contaminants. With the loss of the honey bee, human food production would be drastically reduced. With wind-pollinated grains and arduous hand-pollination efforts the human race would survive. Non-apis pollinators are being studied and may be supported to take on some of the work that honey bees have performed (Brittain, et al, 2013). Without change in the system of food production the future will look very different from the present and likely will result in world famine.

CHAPTER 5

TALL GRASS PRAIRIE TO DEVELOPED BIOME

> What a thousand acres of *Silphiums* looked
> like when they tickled the bellies of the buffalo
> is a question never again to be answered,
> and perhaps not even asked....
> It is easy now to predict the future; for a few
> years my *Silphium* will try in vain to rise above
> the mowing machine, and then it will die.
> With it will die the prairie epoch.
>
> --Aldo Leopold, A Sand County Almanac

There are many reasons why bee-friendly areas are necessary within modern cities. There have been scientific studies conducted that support the notion that cities can be health refuges for bees. The city of Berlin, Germany is home to over 50 million bees from 2100 colonies (Bethge, 2008). The human population in Berlin is a mere 3 million. Moving bees to the city is a paradigm shift, a revelation, to what many believe should be healthy and what our cultural collective conscious proclaims as healthy. The "country" with its fresh air and wide open spaces is the epitome of this notion of healthful habitat. However on further examination of the United States and European landscapes we find that the effects of industrialized agriculture have made the bee habitat of rural landscapes less favorable than that of the urban landscapes.

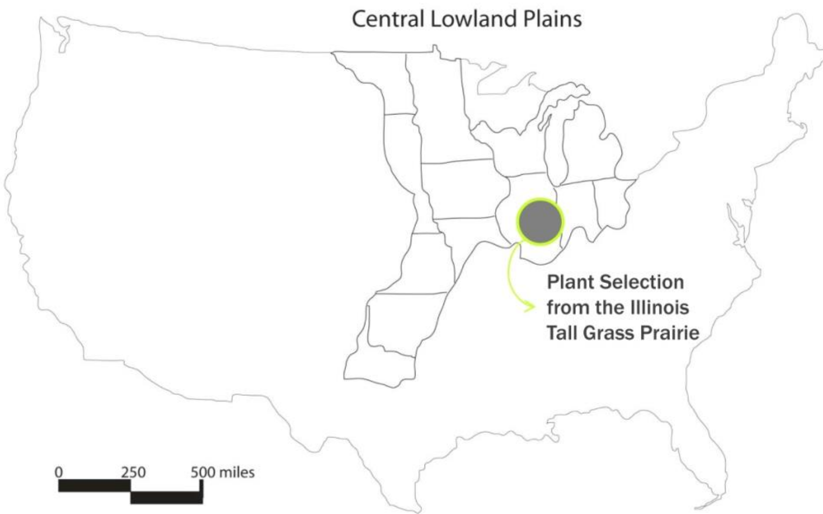


Figure 16. Converting a Biome. The Illinois tall-grass prairie prior to the first settlers in 1830 would have had over thirty-three different pollen- and nectar-rich plants to support the honey bees. See page **45** for a list of plants that existed within the circle in the image.

THE PRAIRIE PRE-SETTLEMENT

Apis mellifera, the European honey bee came to the New World in 1600. European honey bees are reported to have moved through Illinois before 1800 when they were first recorded west of the Mississippi (Horn, 2005). This was prior to the first pioneers who established settlements there between the years 1830 to 1870 (Smith, 1992). The numbers of plants the bees would have encountered to support them in this new land were abundant and have been well-studied. In the Great Prairie Region, the list includes over thirty-three different plants that would have supplied the nectar and protein needed to support hives throughout the foraging period (Ladd and Frank, 2005). Though little native prairie still exists, at one time 240 million acres of land were covered in what would have been excellent bee pasture-land (Smith, 1992). This all disappeared in a single human lifetime, less than 70 years, when the prairie wilderness was converted to agriculture and forever changed to feed the nation and the world (Smith, 1992).

Figure 17. The prairie after the invention of the steel plow. Illinois was wet and the soil was difficult to plow until 1850 and the invention of the steel plow. This along with the inclusion of tile drains allowed the rich and diverse native vegetation to be changed to large monoculture fields through industrialized agriculture.

The Prairie Post-Settlement

This same area when studied today has changed significantly from the initial macrobiotic cover to agriculture. It has gone from a healthy biome with a diversity of plant life that supported many organisms to large, monoculture expanses of industrial agriculture. The face of the prairie changed with the advent of modern agricultural industrialization in Illinois. It began with John Deere's invention of the steel plow in 1850 and with the inclusion of tile drains throughout Illinois to alter the natural wet lands and alleviate flooding. The land has become acres of corn and soybeans, blooming approximately one month annually. Even the kitchen gardens, which were part of this area when settlers first established homes here, have disappeared to make way for larger corporate farms. This system leaves little to support the native habitat and has created a virtual desert for pollinators. Throughout these 150 years relatively few individuals have reflected on the loss of this ecosystem. With less than 3 % of prairie land left across the United States the magnitude of what has been destroyed goes unrealized (O'Shields, 2006). There are an increasing number of scientists attempting to bring a semblance of balance to the agricultural lands.

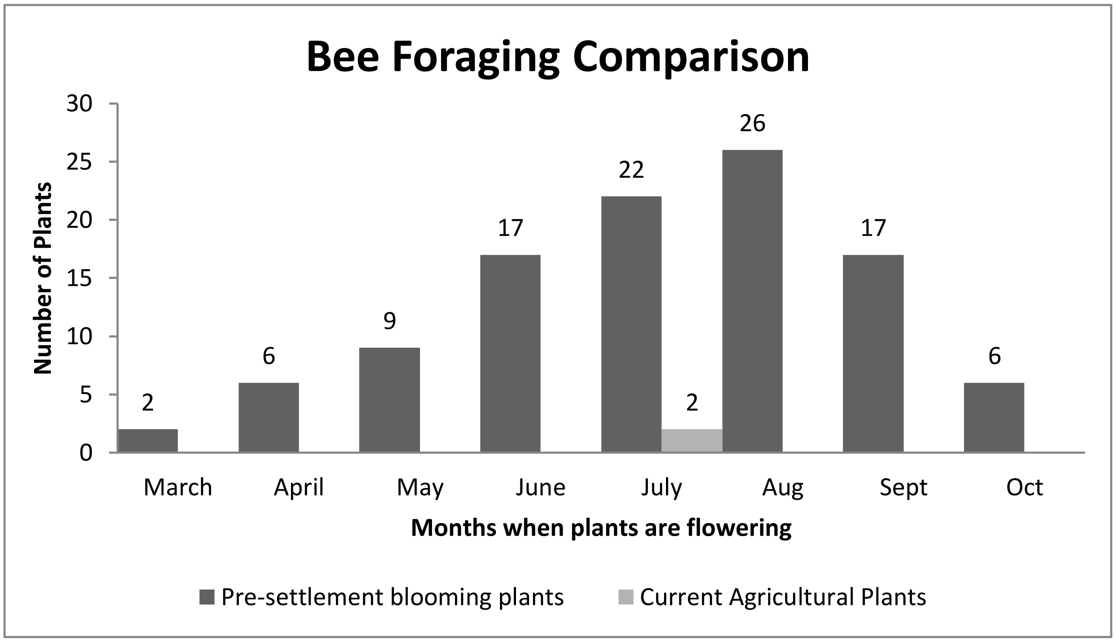


Figure 18. Bee foraging comparison of pre-settlement blooming plants verses current agricultural plants in the area known as the Illinois tall grass prairie. The number of blooming plants prior to the settlement of Illinois was diverse and the timing was vast. Due to current agriculture practices this area of Illinois is now a desert for bee forage.

With industrial pesticides fighting ever adapting and ever growing invasive species (Ladd and Frank, 2005) finding a balance will most likely take much more time than it took to originally convert the prairie landscape.

Table 1. Pre-Settlement Blooming Plants

Scientific name	**Common name**	**Bloom months**
Phlox pilosa	Downy phlox	March-May
Sisyrinchium albidum	Blue-eyed grass	March-June
Polytaenia nuttallii	Prairie parsley	April-June
Penstemon digitalis	Foxglove beards tongue	April-June
Lithospermum canescens	Hoary puccoon	April-June
Zizia aurea	Golden aleanders	April-August
Rosa setigera	Prairie rose	May
Parthenium integrifolium	American feverfew	May-August
Solanum carolinense	Horse-nettle	May-October
Iris virginica var.shrevei	Wild blue iris	June
Asclepias syriaca	common milkweed	June-August
Petalostemum purpureum	Purple prairie clover	Jun-August
Petalostemum candidum	White prairie clover	June-August
Ratibida pinnata	Drooping cone flower	June-August
Eryngium yuccifolium	Rattlesnake master	June-September
Potentilla arguta	Prairie cinquefoil	June-September
Physostegia virginiana	False dragonhead	June-September
Rudbecckia hirta	Black-eyed susan	June-October
Rudbeckia triloba	Brown-eyed susan	June-October
Vernonia missurica	Missouri-ironweed	July-August
Liatris pychostachya	Prairie blazing star	July-August
Pycnathemum virginianum	Common mountain mint	July-August
Amorpha canescens	Lead plant	July-September
Silphium integrifolium	Rosinweed	July-September
Silphium tere-binthinaceum	Prairie-dock	July-September
Silphium laciniatum	Compass plant	July-September
Lespedeza capitata	Round headed bush clover	July-September
Liatris cylindracea	Blazing star	July-September
Monarda fistulosa	Wild Bergamot	July-September
Solidago rigida	Rigid goldenrod	August-September
Aster novaeangliae	New England aster	August-October
Schizachyrium scoparium	Little blue stem	August-October
Lobelia cardinalis	Cardinal flower	August-October

Table 2. Current Agricultural Plants

Scientific name	**Common name**	**Bloom months**
Zea mays L.	Grain Corn	July
Glycine max (L.) Merr.	Soybeans	July

URBAN ENVIRONMENTS BY COMPARISON

Compare the plots in the country with sites in a modern and continually greener cityscape and the results may seem surprising. Due to parks, green roofs, suburban yards and public right-of-way there are large spaces that can support bee habitats. David Aston, chair of the British Beekeeper Association, recently commented in an article for BBC News that because of the monoculture outside of cities bees are healthier in the city (Black, 2010). Finding more plant diversity, the bees are better able to combat many of the pests and diseases that plague modern hives. Knowledge and change in our urban systems must also occur to maintain bee havens; for example, cosmetic pesticide use and genetically sterile plants are just two such issues. Cosmetic pesticide use is the use of chemicals to kill pests for purely decorative or aesthetic reasons. Generically sterile plants have been developed to keep pollen down, to keep plants from spreading in an uncontrolled fashion and in turn keeps pollinators away.

The reasons why designers need to create ecologically sustainable living spaces are many. Limited resources, the limited adaptability of ecosystems to continue functioning indefinitely are just two of the most important (Patchett and Wilhelm, revised Mar 2008). Patchett and Wilhelm (revised Mar 2008) state it very well:

> The health of an ecosystem or a culture degrades in accordance with the degree to which it destabilizes or simplifies itself and there comes a time when there is not enough diversity within the system, with either enough memory of the past or enough potential for the future, to continue. The evolution of a system so compromised ceases.

Humans have built environments, through technological advancement that attempts to control the physical and biological environment. Use of advanced technology has enabled human habitats to appear disconnected from natural systems that are often unpredictable and uncontrollable. These environments remain dependent on natural processes despite efforts to subdue nature with technology. Water pollution, heat island effect, and smog are all inadvertent by-products of a system that is out of balance. Creating habitat within the current urban desert will aid in bringing about a greater balance.

Urban Beekeeping

The amount of quality bee pasture in the U.S. has been declining consistently over the last half century, largely because of changing agriculture practices (vanEnglesdorp and Meixner, 2010). Chemicals have made it unnecessary to rotate legumes in some systems and have cut down on weed (wildflower) production. Open cow pasture has been reduced and harvesting before bloom for crops such as alfalfa have reduced foraging areas (Naug, 2009).

In recent years several cities have begun to bring honey bee hives into the urban fabric. Beehives in cities of developed countries such as Germany or the United Kingdom actually produce more honey than those in the countryside (Deelstra and Girardet, 2008). According to Jurgen Hans, chairman of Berlin's beekeeper association, "Cities are ideally suited for bees" (Bethge, 2008). Union Nationale de l'Apiculture Francaise (UNAF) affirmed this result, stating that urban bees enjoy higher temperatures and a wider variety of plant life for pollination, while avoiding ill effects of agricultural pesticides (Roussel, 2006).

The Fairmont Royal York Hotel in Toronto Canada has hives on the roof and the honey they produce is served in their restaurant. This may be a gimmick to get people in the door but the hives are being supported and vegetables have been planted for the bees to pollinate as well as to also serve in the restaurant. A study where green roofs provide habitat for urban bees in Toronto, found a diverse presence of bees on planted roofs. Through this research scientists believe that some of the effects of development on bees within an urban area may be offset by green roofs (Colla, Willis and Packer, 2009). It is clear that additional research is necessary to ascertain possible positive effects of urban bee habitat development on bee populations. However, this research cannot be accomplished without such areas to study (Hernandez, Frankie and Thorp, 2009). Parks, yards and open urban areas are a great first start. According to one ecologist a single hive could serve an urban area of over 4 square miles (Alberti, 2008).

Within the United States, the Universities of California at Davis and at Berkeley are striving to interweave bees and the urban fabric on a grassroots level (Quest, 2007). The Urban Bee Project is one of these efforts. This project is attempting to teach citizens how to create bee-friendly environments in their own yards. Gordon Frankie, an entomologist at University of California-Davis, has created a demonstration garden and educational materials to aid farmers in planting riparian buffers and unusable edges of their land. Vinson et al. (2004) have provided lists of beneficial, well-timed, plants that will continuously attract bees throughout the foraging season to supplement the flowering times of the farmer's commercial food crops. This ensures that when the agricultural crops are in flower and in need of pollination the bees are within foraging distance and will be available to provide this service (Quest, 2007). There is still fear and resistance to supporting bee hives and foraging, though. On February 4, 2010 the Howard County council in Maryland voted 4-0 to make major restrictions on beekeepers based on fear of the insects (Flottum, 2010). This reinforces the reality that there is still a great deal of work to be done to educate the public about the need for bees and bee habitat in urban areas. The good news is that there are individuals and organizations attempting to create educational opportunities. One of the calls to action from the National Research Council Committee on the Status of Pollinators in North America is to educate the public in ways to support pollinator numbers (Committee on the Status of

Pollinators in North America, 2007). This education cannot be done in a vacuum; it must be done while simultaneously working to design and build more sustainable cities.

CHAPTER 6

HONEY BEES IN CRISIS

> The lack of human contact with nature
> has inured and possibly blinded us to the
> terrible damage we do to our planet.
>
> --Douglas Farr, *Sustainable Urbanism*

Bees as the Selected Species

All insects matter; they are "the little things that run the world" (Hunter and Hunter, 2008). There are two main reasons for the selection of honey bees as the focus for this project. First, honey bees are one of the most practical and widely used indicator species for assessing habitat health (Celli, 2003). Although this is not a direct aspect of this study, it affects opportunities to gauge the success of environmental design once it has been implemented. When considering ways to measure and assess habitat there are many options but many years of scientific research conclude that one of the most practical ways to assess habitat includes the use of indicator organisms (Frankie, O'Keefe and Vinson, 2004). Honey bees are a good biological indicator of environmental contamination because they are susceptible to residual substances and their tendency for bioaccumulation results in a high rate of mortality (Porrini et al., 2003).

The second and most compelling reason to study bees is that they are the main pollinator for agricultural crops in the United States; however, over the past three years there has been a rapid decline of social bee species. The honey bee is one of the most important pollinating insects worldwide, and with numbers dramatically declining crop production is in jeopardy (Kaplan, 2008). Global dependence on managed pollinators has increased rapidly since 1991 and the industry has been struggling to meet the demands (Aizen, 2009). Development of bee habitat that will both improve the urban human experience as well as sustain bee colonies may bolster the sustainability of the species. Hernandez, Frankie and Thorp (2009) found an overall negative effect of urban development on urban bee species. Except in areas where plants were cultivated with a focus on specific bee species, bees could not be found foraging. This shows bees as a resilient urban species. If potential pollen and nectar plants are planted in ways that are supportive of bees then the potential for bee foraging in those areas is highly increased.

Colony Collapse Disorder

Over the last few years bee decline has been in the world news to an escalating extent. Bee decline is not a new phenomenon; since the 1980s honey bee numbers have been dropping (Kaplan, 2008) but the recent losses have differed significantly from those of the past. The difference is a result of what scientists call Colony Collapse Disorder (CCD). This disorder “is characterized by the disappearance of all adult honey bees in a hive while immature bees and honey remains” (Kaplan, 2008). The problem was first reported in Florida on November 2006 by a professional beekeeper of 40 years, Dave Hackenberg (Benjamin and McCallum, 2009). In October of that year Hackenberg dropped off several loads of bees in Florida that had been pollinating in Pennsylvania and New York - all appeared healthy. Upon his return in November less than ten percent of his hives were still alive (Schacker, 2008). He noted the strange circumstances that almost all of the adult bees from his 400 hives were missing. He searched the ground, the other hives, anywhere he could think of, but thousands of bees were just gone (Langworth and Henein, 2009). He initially contacted the Florida state apiarist, who told him it was just *Varroa* mites (Jacobsen, 2008). Hackenberg had been dealing with the mites for many years and knew this dilemma was different.

Varroa destructor is an arachnid and thus is in the same class as spiders and ticks. Originally from the Far East, the mite adopted the western honey bee *Apis mellifera* as a host some time during the twentieth century. In 1987 the first *Varroa* mites were found in the United States. One-quarter of professional beekeepers in the country went out of business due directly to the destructive nature of these mites (Jacobsen, 2008). *Varroa* mites weaken a hive by sucking the blood of the bees. The adults are often hosts, but the real damage to the hive occurs in the brood chamber. A pregnant adult mite hides in a cell with a bee larva. It is able to remain perfectly still for days to avoid detection. Once the nurse bees cap the cell, the adult mite lays her eggs. When the eggs hatch the new mites begin feeding on the larval blood, mate, then scramble to a new cell once the original one has been opened. The wounds on the newly emerged bee are susceptible to bacteria, fungi and various viruses. The weakened hive may eventually die due to malnutrition caused by its inability to efficiently forage (Jacobsen, 2008).

This was not what Hackenberg was witnessing in his bee yard. He gathered the few dead bees he could and went to ask the Pennsylvania state apiarist to look into the matter (Benjamin and McCallum, 2009). The first tests came back revealing a number of major issues. The bees had "scarring on the digestive tract, swollen kidneys and evidence of a fungal or yeast infection in the sting gland (Benjamin and McCallum, 2009). The immune systems of Hackenberg's remaining bees appear to have failed. This new problem appeared to be more akin to AIDS in humans than a single disease or pest. AIDS does not kill people outright; it leaves the immune system susceptible to other viruses or diseases. For example many AIDs patients actually die from pneumonia and not actually from AIDs. Hackenberg's bees did not seem to have a new undescribed disease but instead they appeared to have an enormous number of known pathogens attacking them at once (Jacobsen, 2008).

A flurry of small-scale research studies were conducted with bees and beekeepers. A report was compiled and the blame for this new malady was focused on the beekeepers' practices. Hackenberg again knew it was more than what the scientists could detect. By the spring of 2007 he had lost 2,000 of his 3,000 colonies and he found he was no longer alone (Benjamin and McCallum, 2009). According to Barrionuevo (2007) more than a quarter of the country's 2.4 million bee colonies were lost that first year. These numbers were based on an estimate from Apaiary Inspectors of America (2008), a group that tracks beekeeping in the United States. This would be a loss of over 30 billion individual honey bees (Jacobsen, 2008). The issue is not isolated to the United States. Canada, France, Spain, Portugal, Italy, Greece, Germany, and Poland have all reported eerily similar issues with their hives (Jacobsen, 2008).

According to data collected from September 2006 through April 2007, twenty to thirty percent of managed colonies in the United States had been affected (Watanabe, 2007). The winter of 2010-2011 witnessed the highest over-winter losses ever reported in Michigan, Wisconsin, New Hampshire and Illinois each with losses to their hives of 55% or higher. The national average loss was 38.7% even though one-third of the survey respondents had no losses. The entire one-third falls into the category of backyard/hobby apiarists (Spleen et. al., 2013). During the past five years since CCD, losses have all been around 30%. Colony Collapse is just one of the issues that is listed as causing these overwinter losses but those beekeepers that listed it as a cause had greater individual losses than apiarists who did not report CCD as a cause (Spleen et. al., 2013). In a statement before the House of Representatives Committee on Agriculture in 2007, May Berenbaum (Professor and Head of the Department of Entomology at the University of Illinois, Urbana-Champaign) stated that even prior to the discovery of CCD honey bees were experiencing a steep decline. She stated that if the rate of decline continued at the rates documented from 1989 to 1996, “managed honey bees will cease to exist by 2035” (Berenbaum, 2007).

Blame has shifted and numerous suggested causes have been considered including different types of mites, viruses, fungi, even cell phones, but all have been ruled out as the single cause. Even the digestive tracts of the bees have been studied. Honey bees have a relatively simple and consistent gut microbiome (Marinson et al., 2011). Scientists have found deviations in the gut flora in hives that have collapsed when compared to healthy ones. These deviations in this flora could be a biomarker for, or directly related to, a yet unknown disease (Cornman et al., 2012). To this date there has been no consensus on what is killing the bees. The one thing that has been agreed upon is that symptoms presented by CCD are most likely caused by a synergy of many different factors (Cornman et al., 2012). The already known stressors and ailments that strain the bees are thought to be combining in new ways all contributing to this crisis.

This loss is an environmental tragedy, but it has economic costs as well. Kaplan (2008) states the economic value of bees in agricultural pollination of 130 different crops is more than $15 billion. The original decline in numbers was firsts documented by beekeepers in the business of taking hives cross-country (Figure 19). Honey bee hives are loaded by the hundreds on 18-wheel trucks which then travel in search of pollination work (Barrionuevo, 2007). It is not uncommon for a beekeeper to travel 37,000 – 40,000 miles per year to pollinate four or more different crops (vanEngelsdorp and Meixner, 2010). This practice has added stress to the hives and resulted in the diets of the traveling bees that consist of "artificial supplements, concoctions akin to energy drinks and power bars" (Barrionuevo, 2007). Hive rental costs can be as much as $150 to $200 per hive (Watanabe, 2007). The transport of these hives across the country will likely lead to the further spread of organisms that contribute to CCD (personal communication, Marlin, 2009).

Figure 19. Commercial Pollinators
It is not uncommon for a beekeeper to transport hives 37,000 – 40,000 miles per year to pollinate four or more different crops. During 2005 hives were even flown into California from Australia to help pollinate the almond crop.

The cause of CCD is still a mystery. Even though many researchers are dedicated to understanding it and some progress has been made, the process has been slow. In October 2010 scientists from the United States military and the University of Montana in Missoula found similarities among hives suffering from CCD that do not exist in healthy hives. But knowing that these ailing hives have a combination of a virus and fungus present does not create healthier hives; additional research into the underlying causes of the disorder must be conducted (Johnson, 2010). Scientists have theorized there are actually many reasons why bees are in decline and that CCD is one more symptom of a system being overload with stressors. The greatest losses of bees within hives not suffering from CCD occur through the winter: cold temperature and starvation are the main cause (Flottum, 2010). The association of bee health and weather has been well documented by apiarists since Aristotle's time (Benjamin and McCallum, 2009). Cold temperature losses are fairly straight forward; bees revert to "winter clusters," where bees huddle very tightly together with the queen in the center (Flottum, 2010). The bees to the outside will die as the temperatures dip too low, protecting the bees and the queen toward the inside. Starvation within a hive is more complicated because it does not just affect the individual bees but places a drain on the entire hive. These malnourished hives are more prone to disease and less tolerant of pesticide exposure (Seeley, 1995).

One of the most studied bee epidemic prior to CCD according to Benjamin and McCallum occurred during the spring of 1906 there were major bee losses on the Isle of Wight in England that were originally blamed on the weather. Spring appeared to arrive early with excessive heat yet the weather turned and it snowed in April (Benjamin and

McCallum, 2009). This is the most famous bee epidemic prior to CCD. After years of discourse and scapegoating, Lesley Bailey, a British parasitologist, using one of the first electron microscopes, was able to identify the killer in the 1950's. The culprit was Chronic Paralysis Virus (CPV), which caused the bees to lose the ability to fly (Benjamin and McCallum, 2009). Ultimately Bailey believed that the disease was not new but that the bee's weakened immune system was ultimately to blame for the resultant number of die-offs (Benjamin and McCallum, 2009). For this newest epidemic, CCD, once the underlying cause is clearly established action can be taken to control the epidemic. The complete set of factors responsible for CCD must be determined if there is any hope of sustaining bee populations. With advanced science, it should not take fifty years to solve the problem as with CPV on the Isle of Wight. In the mean-time, support to reduce multiple stressors may help to reduce the effects of CCD. The role bees play in the system is much too great to be ignored.

Pesticides

The devastating cost to beehives when living and foraging near pesticides is a relatively modern problem. Pesticides as they are being developed and used today are an outgrowth of World War I (Langworth and Henein, 2009). Chemical warfare was being developed to use against soldiers during the war; the large chemical companies switched the focus from human targets to insects in what was advertised as a logical innovation (Langworth and Henein, 2009). The first modern synthetic chemical insecticide was dichlorodiphenyl trichloroethane (DDT) officially released in during the 1940s for use on malaria, typhus and for us on crops; by 1953 it was being used on every household

Figure 20. Penn Salt Chemical Advertisement. First run in 1947 as Time Magazine Advertisement. DDT was seen as a miracle product. The whole ad states that DDT kills a host of pests and is a benefactor to humanity. DDT was later pulled from the market for environmental reasons.
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http://www.flickr.com/photos/crossettlibrary/with/5559380252/#photo_5559380252

surface to remove all types of insects. The negative effects these chemicals have on the ecosystem were brought to public awareness by Carson (1962) in her groundbreaking book *Silent Spring.* It took until 1972, an additional ten years, for the United States to ban the use of DDT due to environmental hazards (Benjamin, 2009). After the Second World War scientists began working on different chemicals and in 1958 deadlier more toxic chemicals were being applied to crops such as dieldrin and heptachlor (Benjamin and McCallum, 2009).

Today's growers are given a multitude of choices when it comes to the chemicals they have available to them to kill pests and eradicate fungi; some of the deadliest are widely available and take no training to use. Carbaryl, produced by GardenTech as the common household product Sevin, has been found to be only moderately toxic to mammals and is one of the most widely used in gardens and landscapes. It is, however, highly toxic to honey bees and many other beneficial insects and mites (DeAngelis, 2010). Even deadlier are the seven different types of neonicotinoid products that were first registered for use in the mid-1990's: acetamiprid, clothianidin, dinotefuran, imidacloprid, thiacloprid, and thiamethoxam (Hopwood et. al., 2012). These synthetic products mimic the natural effect that nicotine has on insects as a nerve poison. It interferes with the way the nerves communicate with each other and the muscles in the body, crossing signals and causing neurons to misfire (Jacobsen, 2008). The products may be applied as seed coatings, soil drenches, granules, foliar sprays, or by direct injection into tree trunks, or by adding it to the irrigation water (Krupke, et. al., 2012). The most common of these neonicotinoids are imidacloprid and clothiandidin. These dangerous substances may not kill the bees and other pollinators outright but given at sub lethal doses honey bees experience problems with flying and navigation. They also exhibit slower learning of new tasks which impacts the worker bee's ability to forage for food theoretically increasing the risks of starvation within the hive (Hopwood et. al, 2012).

Systemic insecticides are those in which the poison is absorbed by the plant and circulates throughout the plant's tissue (Jacobsen, 2009). It is not applied as a spray that sits on the leaves of the plant but becomes part of the plant tissue; thus even after a rainfall an insect could eat the leaves and be poisoned. What makes it deadly to pollinators is that the pollen and nectar have also absorbed the poison so when this nectar is concentrated to make honey to feed the brood or for winter rations the poison also becomes concentrated (Hopwood et. al, 2012). Systemic insecticides have an additional draw-back. The toxins are persistent in the plant tissue for up to a year and may remain in the soil for in excess of three years. The new seedlings

Figure 21. Top Three Greatest Toxic Threats to Honey Bees. Pesticide use can be devastating to honey bee populations. Citrus crops need bees to pollinate the flowers, corn can rely on the wind for pollination but the silks still attract bees from the surrounding area (Flottum, 2009). The greatest threat is the cosmetic use of pesticides on residential yards and gardens (Schacker, 2008).

growing in the same soil may take up the insecticide so when the plants are treated additional times in the future the toxins accumulate in greater concentrations.

Farmers and commercial growers are fighting this balancing act with toxins every year but one of the greatest areas of toxicity to pollinators is the residential yard and garden. This cosmetic or ornamental use of pesticides is the greatest threat to urban and suburban honey bee populations (Figure 21) (Schacker, 2008). One reason for this is that a homeowner treating their garden plants is approved to apply 12 to 16 times the amount of imidacloprid that would be allowed in an agricultural setting and that is if the homeowner is following the directions and not over applying it (Hopwood et. al., 2012). Ninety million pounds of pesticides are applied to residential lawns alone in the United States annually using more pesticides per acre than any food crop (Schacker, 2008). It takes no more than to walk down the local home and garden center pest isle to see another reason for the problem. Neonicotinoids are prevalent in an unending number of products from every chemical company possible. Bayer Corporation has been the one in the news due to the French law suits and protests. They have an ever increasing number of these pesticides on the market such as: *Bayer Advanced All-In-One Rose and Flower Care Granuals; Bayer Advanced 3-in-1 Insect, Disease and Mite Control; Bayer Advanced 12 Month Tree and Shrub Insect Control; Bayer Advanced 12 Month Tree* *and Shrub Protect and Feed; Bayer Advanced Season Long Grub Control and Lawn Revitalize;* and *Bayer Advanced Fruit, Citrus and Vegetable Insect Control* to name just a few. Ortho products such as: *Ortho Flower, Fruit and Vegetable Insect Killer; Ortho Rose and Flower Insect Killer; Ortho Bug-B-Gon Year-Long Tree and Shrub Insect Control;* and *Ortho MAX Tree and Shrub Insect Control* are also using these chemicals. In addition to the well-known plant neonicotinoid pesticides: Merit, Marathon, Meridian, Zylam, the popular pet flea and tick applications Advantage and Advantix have neonicotinoids as their main active ingredient.

Proactive planning and organic care are the best alternatives to using these toxic chemicals. Healthy plants are less likely to become diseased or infested but if something does affect the plant then utilizing integrated pest management (IPM) is the best approach. The IPM approach is the use of cultural, biological and/or chemical methods in a sequence to manage economic, environmental and health risks (Krebs, 2008). The first step is to identify the culprit or condition and then to apply a treatment for that specific culprit or condition while seeking the underlying causes. Natural remedies such as having plants tested for mineral deficiencies and correcting the imbalances work on the foundational problem, not just the resulting damage, so they are often not quick fixes. They may solve many problems for the future health of the plant but often the first noticeable signs or problems are the actual infestation or lesions on the plant; these may be life-threatening. Under these circumstances other options may not work and chemical insecticide, herbicide or fungicide must be used.

When cultivated plants are under attack from pests such as the invasive Japanese beetle (*Popillia japonica*) it is difficult for a gardener to have patience with more natural, less harmful strategies but even the simple adjustment of timing the spray of pesticides to dusk, when most pollinators are not as active, can go a long way in creating a healthier environment for pollinators. Creating a proactive plan may be the best approach starting with choosing the least dangerous method and working up to more toxic ones. Some beetles may be shaken into insecticidal soap early in the morning to remove them from branches and leaves. Products like *Milky Spore (Paenibacillus popilliae)* may be added to turf areas where it is ingested by beetle grubs. Bacterial reproduction is activated in the grub's digestive system where it feeds on grub tissue. After the grub dies and decomposes, billions of new bacteria spores are released into the soil. Other suggested general use substances from least toxic to most are fatty-acid soap and water, vinegar, boric acid, diatomaceous earth and silica aerogels, botanical pesticides and neem oil. Specific information for pest management can be found on University websites such as University of Connecticut (http://ipm.uconn.edu) (2012), Colorado State University (http://coloradoipmcenter.agsci.colostate.edu/) (2012) and the University of Illinois (http://ipm.illinois.edu/) (2012). The Internet has additional reliable

Figure 22. 1/3 of all food is pollinated by Honey Bees. Most commercial fruit and vegetable production would be seriously affected without the pollination assistance of honey bees. Most grains and legumes would persist so human carbohydrate and protein needs could be met but vitamins and minerals would quickly become deficient.

sites such as the Pesticide Education Center website (http://www.pesticides.org/)(2009) and the Beyond Pesticides website (http://www.beyondpesticides.org/) (2009), both supplying beneficial resources. One thing that must be avoided is the loss of habitat and healthy ecosystems creating a situation similar to that of Maozian County, Sichuan, China where each year thousands of villager must hand-pollinate apple and pear trees because of the decline in natural pollinators caused by pesticides and honey over-harvesting (Ahmad, Partap, Joshi, and Gurung, 2004; Gurung et al., 2003). Knowledge of the damage that pesticides can do is vital but this knowledge must lead to action if the honey bee and other pollinators are to survive in developed areas.

POLLINATION

Fifty-two of one hundred fifteen leading global food commodities depend on honey bee populations and 1/3 of all food production relies on honey bee pollination (Figure 22, Table 3 and 4) (vanEnglesdorp and Meixner, 2010). Yield size which is measured as fruit size, quality or quantity, would be reduced by 40-90% in sixteen major food commodities

Table 3. Commercial Crops that produce higher yields with honey bee pollination.

Name	Aspect Pollination Effects			
black-eyed pea	food		seed	
corn	food		seed	
cotton			seed	fabric
grape	food		seed	
kidney bean	food		seed	
lettuce			seed	
lima bean	food		seed	
soybean	food		seed	
spinach			seed	
string bean	food		seed	
tomato	food		seed	

without honey bees (vanEnglesdorp and Meixner, 2010). When foods, such as pork and dairy, that are indirectly benefited from pollination are considered, 35% of the human diet is affected (vanEngelsdorp and Meixner, 2010). Products such as strawberries, apples, pomegranate, almonds, cucumbers and coffee would be affected as would seeds of broccoli, onion, celery and peppermint. The greatest shortage if not complete loss would come in items such as kiwi, watermelon, cherries, zucchini, cranberry, pumpkin, and macadamia nuts to name just a few (Sammataro and Avitabile, 1998). The main issue is that honey bees

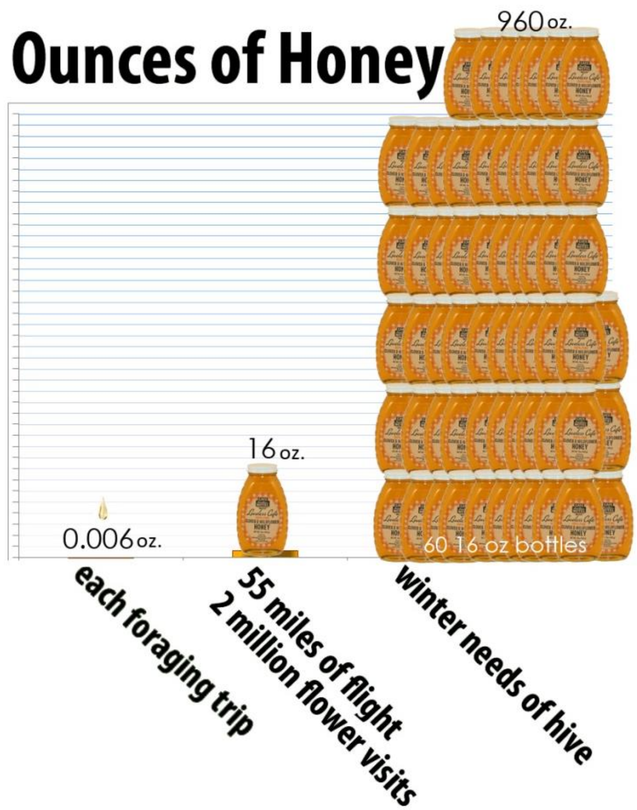


Figure 23. Honey bees are prolific workers. A hive in the Midwest must produce in excess of 960 ounces of honey during the foraging season. That is the equivalent of sixty 16 ounce bottles of honey. Each bottle contains honey that the bees had to fly an average of 55 miles to produce. In order to produce the needed amount of honey for the entire winter the bees of one hive will travel over three thousand miles (derived from Canadian Honey Council information 2016, accessed Oct. 14, 2016) http://www.honeycouncil.ca/chc_poundofhoney.php

are powerhouse pollinators (Higgins, 2004). A bee can fly approximately 15.5 miles per hour and can cover a huge distance traveling up to 10 miles from the hive (Seeley, 1995). Colonies will also continue to pollinate surrounding vegetation, gathering nectar and pollen until the hive's combs are completely filled and there is a modest reserve of pollen. An average colony of 50,000 individuals has an annual nectar budget of about 264 lbs and pollen budget of 44 lbs (Seeley, 1995).

Table 4. Commercial Crops that depend on honey bee pollination for production

Name	Aspect Pollination Effects			
alfalfa			seed	cattle feed
allspice		spice	seed	
almond	food		seed	
apple	food		seed	
apricot	food		seed	
artichoke	food		seed	
asparagus	food		seed	
avocado	food		seed	
banana	food		seed	
basil			seed	
black berry	food		seed	
black currant	food		seed	
blueberry	food		seed	
boysen-berry	food		seed	
broccoli	food		seed	
buck wheat			seed	
cacao (chocolate)	food		seed	
canola oil	food		seed	
cantaloupe	food		seed	
caraway		spice	seed	
cardamom		spice	seed	
carrot			seed	
cashew	food		seed	
celery	food		seed	
cherry	food		seed	
chestnut	food		seed	
coconut	food		seed	
coffee	food		seed	
coriander		spice	seed	
cranberry	food		seed	
cucumber	food		seed	
diditalin				medicine
dill		spice	seed	
echinacea	food		seed	
eggplant	food		seed	
elderberry	food		seed	
ephedrine				medicine
etoposide				medicine
fennel		spice	seed	
flax	food		seed	
gooseberry	food		seed	
gourd	food		seed	
grapefruit	food		seed	
guar bean	food		seed	
guava	food		seed	
lemon	food		seed	
verbena			seed	
lime	food		seed	
longan	food		seed	
loquat	food		seed	
lychee	food		seed	
macadamia	food		seed	
mango	food		seed	
musk melon	food		seed	
mustard		spice	seed	
nectarine	food		seed	
orange	food		seed	
oregano			seed	
peach	food		seed	
pear	food		seed	
peppermint			seed	
persimmon	food		seed	
pineapple	food		seed	
plum	food		seed	
pome-granate	food		seed	
potato			seed	
pumpkin	food		seed	
raspberry	food		seed	
red currant	food		seed	
reserpine				medicine
sage			seed	
squash	food		seed	
strawberry	food		seed	
sunflower	food		seed	
tangelo	food		seed	
tangerine	food		seed	
tea plant			seed	
teniposide				medicine
tomatillo	food		seed	
walnut	food		seed	
watermelon	food		seed	
zucchini	food		seed	

Under favorable conditions this means an average of 100 lbs or more of honey and 2 lbs of pollen will be produced over what is necessary for the hive to survive (Flottum, 2010). Considering two million blooms must be visited for every pound of honey, there is justification for the term ‘powerhouse’ (Flottum, 2010).

CONSTRUCTING HABITAT

The tragedy that CCD creates is an opportunity to establish a design protocol to aid in the development of healthier honey bee habitats. The specific and technical requirements of this kind are difficult to attain within the constraints of a generalized professional practice. Bees need pollen from a range of plants throughout the foraging season (Black, 2010). The foraging season can be defined as any time that the temperature is above 55 degrees Fahrenheit (Flottum, 2010). Recent research found that bees had healthier immune systems when fed pollen from a range of plants as opposed to those who were fed pollen from a single type (Black, 2010). These plants may be placed across a radius of about 10 miles from the hive, but the closer this diversity of plants can be found the longer the individual lives of the bees and the stronger the hive is in general (Black, 2010). The fact has been established by researchers that “[t]he flight distance accumulated by a forager has more of an influence on her life span than chronological age” (Winston, 1991). Most forager bees will only live an additional 4 or 5 days after her first flight but researchers have found that the chronological time has much less to do with honey bee lifespan then total distance the individual has flown. The majority of foraging bees will die after just 487 miles of flight, no matter the amount of time that has passed (Winston, 1991).

CHAPTER 7

ESTABLISHING CRITERIA FOR A MODEL

> You never change things by fighting
> the existing reality.
> To change something, build a new
> model that makes the existing model obsolete.
>
> --R. Buckminster Fuller

Metropolitan areas may have the greatest potential for bee habitat establishment but there is a disconnection between the city population needs and the needs of bees. Aesthetics and human function play the greatest role in determining how a space is designed. The individual plants and their contribution to the natural system is only on rare occasion considered. This is not always due to a lack of desire but a lack of knowledge either in importance of these considerations or lack of access to information. Rain gardens a few years ago were unheard of; water flowed off the properties and into storm sewers where it was whisked away to “better” places. Due to education of the public, keeping water on site has become an understandable consideration when re-designing a space (Brown, 2000; Emery, 2013). It is my belief that, if encouraged, many people would choose to support the local habitat, particularly if it inconvenienced them in only small ways. A system needs to be developed to simplify the information about bees and to develop criteria for habitat creation.

General Requirements

To successfully use honey bee requirements as a guide for designing landscapes, one of the first things that must be considered is the seasonal needs of the honey bee population. As stated earlier, bees need a food source and will forage anytime the temperature is above 55 degrees Fahrenheit (Dadant, Inc., 1978). Through three seasons in the Midwest bees need nectar and protein-rich blooms; further south needs may call for year-round consideration. Honey bees need a hive space that gets winter sun but is shaded in summer. It must have wind protection and must have a source of water that is fresh but that has a place for bees to land and reach the water surfaces (Flottum, 2010). Most bee keepers will ensure that basic protection and water are provided for the hive but urban bee keepers do not generally have the space to meet all of the foraging needs of the hive. This takes a community to accomplish. Bees are also sensitive to pesticides, as mentioned earlier, so part of what they need is community agreement to use bee-safe practices and stringent restrictions on the use of highly toxic chemicals.

Scale Selection

Counties, cities, and towns come in all sizes. Breaking down these large areas into manageable, walk-able, neighborhood scale spaces is a first step in analyzing and organizing potential honey bee habitat. The needs and desires of the human residents can then be balanced with the needs of the bees. According to recent research the average American is willing to walk to a destination that is 1/4 of a mile away or 1/2 mile round-trip (APA, 2006). This research can be utilized to establish the parameters of this neighborhood scale space. Using a 1/16 mile radius circle, the perimeter of this neighborhood unit would be approximately 2/5 of a mile; adding to that distance 1/8 of a mile to get to the edge from the center and then back would equal a total walking distance of about 1/2 mile.

The rule of thumb for the apiarist is 1 acre of foraging material per hive (Flottum, 2010). In urban environments built material must be taken into consideration. The 1/16th mile radius circle, neighborhood scale, contains approximately 8 acres in total space. Part of this would be structures, walkways and roads but at least 1 acre could be utilized to support honey bees through the three foraging seasons if it were planted and managed appropriately. By adding multiple neighborhood spaces a metropolitan area could overlap boundaries, creating a bee sanctuary within the municipality.

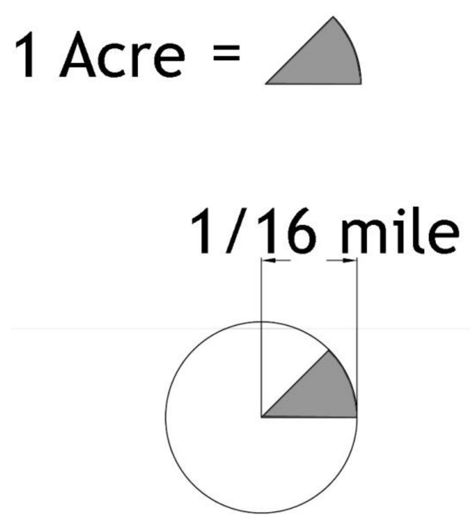


Figure 24. Establishing neighborhood spaces.
A 1/16 mile radius circle with a perimeter of 2/5 of a mile would create a walk-able neighborhood space. Add to the perimeter the 1/8 of a mile to travel to the edge of the circle from the center and then back would equal a total walking distance of about ½ mile. For honey bees the rule of thumb is 1 acre of foraging material per hive. The neighborhood scale contains 8 acres in total space, part of this would be structures, walkways and roads but at least 1 acre could be utilized to support honey bees.

INVENTORY FORM

Discovering and accounting for what is planted in an area of eight acres can be an immense undertaking so a form has been developed to aid

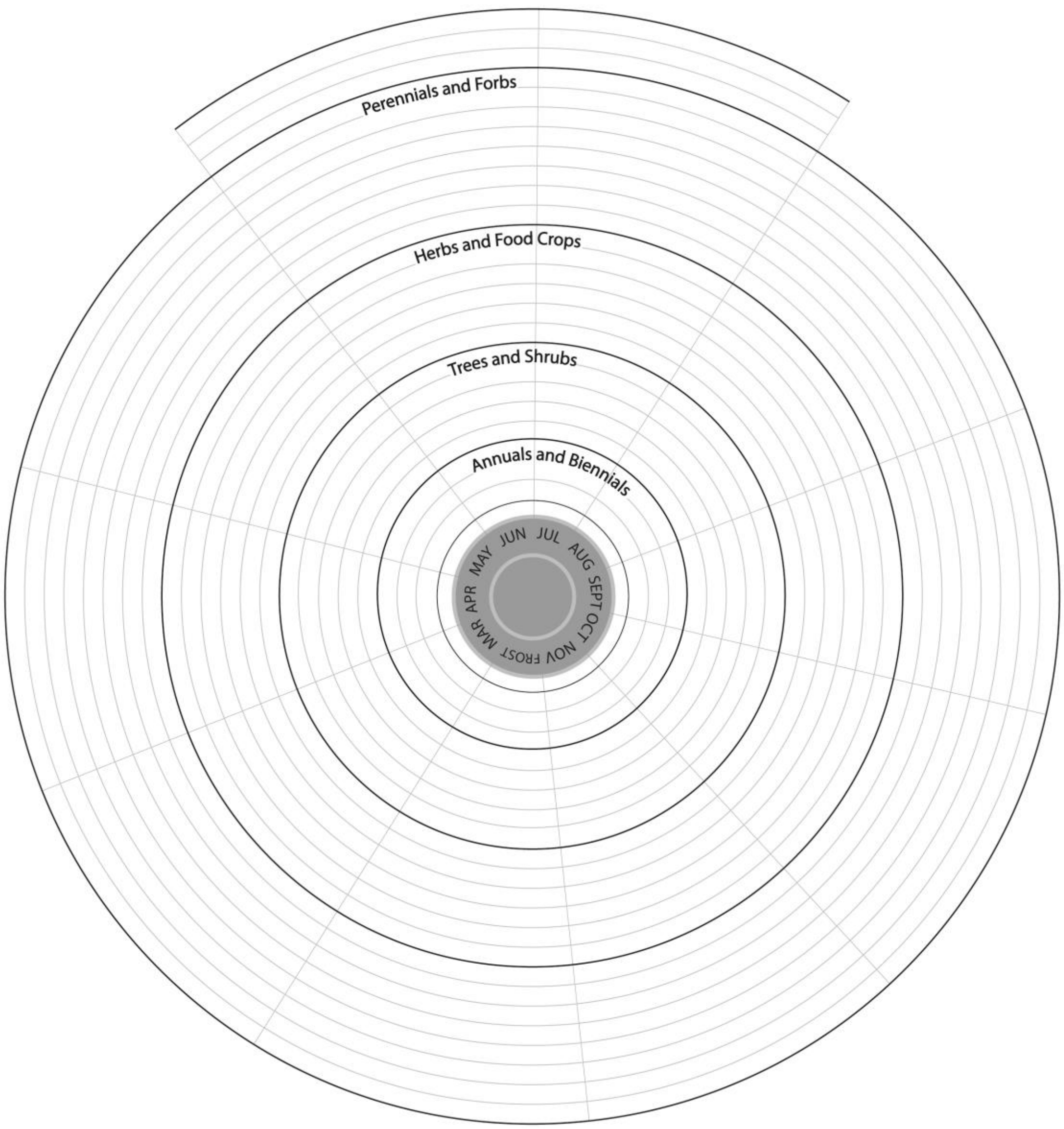


Figure 25. Inventory Form. A resource created to reveal the times when blossoms are present and when foraging opportunities may be scarce. The circle lends itself to this form because seasons are cyclical in nature.

the understanding of what is currently available for bees and where the greatest need for foraging support may exist. Selecting plants for an area is easier through the use of a horizontal grid indicating plant needs and aesthetic style but, when analyzing blooming cycles to determine where there are gaps in a food cycle, a circle is more accessible. Resource availability and the times when these blossoms are present is much more evident when viewing a circle graph. This symbol also reinforces the seasonal nature of the ecological system at work.

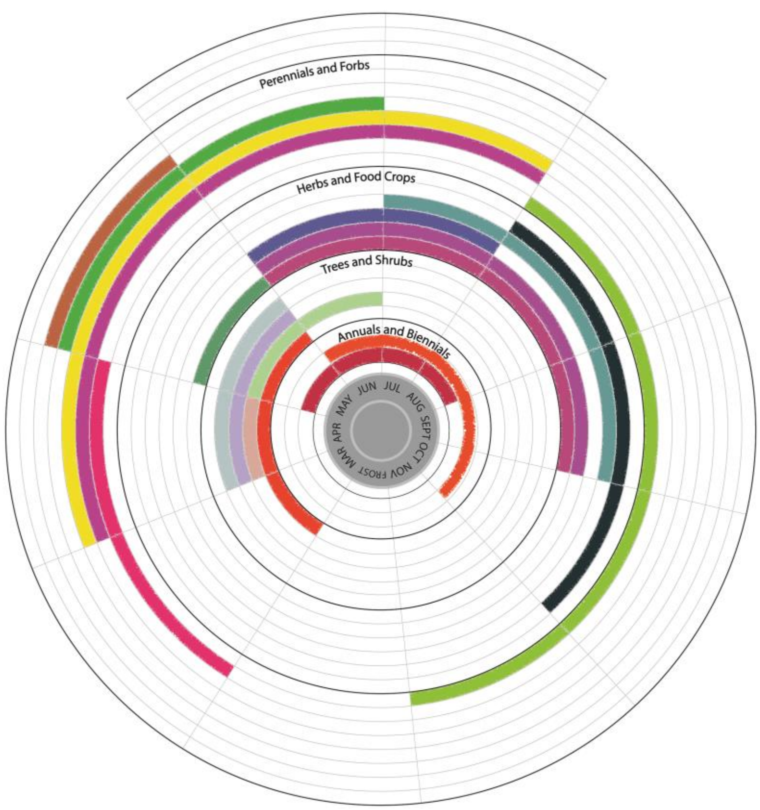


Figure 26. Analysis of a single yard in Galesburg, Illinois. This image clearly shows that the bees' ability to forge in this yard is very limited in the months of March and November. Further analysis of the neighborhood is needed to see if these gaps may be filled in other nearby yards.
Plants were observed 2009-2010

Selection of Plants

The chart of compatible vegetation was developed by determining the best plants for Zone Five using native flora when possible, and when natives were not available supplementing with naturalized non-invasive species to enhance the selection and palette. These suggested plants have been separated into three categories: trees, perennials, and forbs & herbs. Annuals may be used to fill a niche but since they are less reliable year to year than perennials they have not been included in the list, except for garden vegetables, but space is provided to add annuals for consideration on the analysis form.

Table 5 a. Tree Selection Chart (*page 1*).

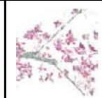
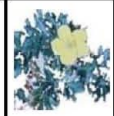
bloom image													
scientific	*Cornus sercia*	*Quercus alba*	*Crataegus crusgalli*	*Carya ovata*	*Aesculus glabra*	*dendron prinophyllum*	*Bur Oak*	*Populus tremuloides*	*Cercis canadensis*	*Juniperus virginiana*	*Amelanchier arborea*	*Corylus americana*	*Viburnum carlesei*
common	Red Osier Dogwood	White Oak	Cockspur Hawthorn	Shag-Bark Hickory	Ohio Buckeye	Roseshell Azalea	Quercus Macrocarpa	Quaking Aspen	Eastern Redbud	Eastern Red-Cedar	Downy Service-Berry	American Hazelnut	Koreanspice Viburnum
height	4-10	50-80	20-30'	70-90	20-40	4-8	60-80	20-50	20-30'	30-65	15-25	10-16	4-6'
spread	4-10	50-80	20-35'	50-70	20-40	4-8	60-80	10-30	25-35'	8-25	15-25	8-13	4-7'
sun	full sun	full sun	full sun to shade	full sun to part shade	full sun to part shade	part shade	full sun	full sun	full sun to part shade	full sun	full sun to part shade	full sun to part shade	full sun to part shade
water	dry to wet	dry to medium	dry to medium well drained	medium	medium	medium	dry to medium	medium	medium	dry to medium	medium	medium	medium
bloom times													
	March	March	March	March	March	March	March	March	March	**March**	**March**	**March**	**March**
	April	April	April	**April**	**April**	**April**	**April**	**April**	**April**	**April**	**April**	**April**	**April**
	May	**May**	**May**	**May**	**May**	**May**	May	May	May	**May**	May	May	May
	June	June	June	June	June	June	June	June	June	June	June	June	June
	July	July	July	July	July	July	July	July	July	July	July	July	July
	Aug	Aug	Aug	Aug	Aug	Aug	Aug	Aug	Aug	Aug	Aug	Aug	Aug
	Sept	Sept	Sept	Sept	Sept	Sept	Sept	Sept	Sept	Sept	Sept	Sept	Sept
	Oct	Oct	Oct	Oct	Oct	Oct	Oct	Oct	Oct	Oct	Oct	Oct	Oct

Table 5 b. Tree Selection Chart (*page 2)*

bloom image										
scientific	*Hamamelis virginiana*	*Potenilla fruticosa*	*Rhus typhina*	*Tilia americana*	*Catalpa speciosa*	*Juglans nigra*	*Liriodendron tulipifera*	*Gymnocladus Dioica*	*Viburnum prunifolium*	*Cornus racemosa*
common	Common Witch Hazel	Shrubby Cinquefoil	Shaghorn Sumac	American Linden	Northan Catalpa	Balck Walnut	Tulip Tree	Kentucky Coffeetree	Blackhaw Viburnum	Gray Dogwood
height	15-20'	2-4'	15-25'	50-80	60-90'	75-100	70-90	60-80	10-15	6-10
spread	15-20'	3-5'	20-30'	30-50	30'	75-100	30-50	40-55	6-12	8-12
sun	full sun to part shade	full sun to part shade	full sun to part shade	full sun to part shade	full sun to part shade	full sun	full sun	full sun	full sun to part shade	full sun to part shade
water	medium	dry to medium	dry to medium well drained	medium	dry to wet	medium	medium	Medium	dry to medium	dry to wet
bloom times	*March*	*March*	*March*	*March*	*March*	*March*	*March*	*March*	*March*	*March*
	April	*April*	*April*	*April*	*April*	*April*	*April*	*April*	*April*	*April*
	May	*May*	*May*	*May*	***May***	***May***	***May***	***May***	***May***	***May***
	June	***June***	***June***	***June***	***June***	***June***	***June***	***June***	***June***	***June***
	July	***July***	***July***	*July*	***July***	*July*	*July*	*July*	*July*	*July*
	Aug	***Aug***	*Aug*	*Aug*	*Aug*	*Aug*	*Aug*	*Aug*	*Aug*	*Aug*
	Sept	***Sept***	*Sept*	*Sept*	*Sept*	*Sept*	*Sept*	*Sept*	*Sept*	*Sept*
	Oct	*Oct*	*Oct*	*Oct*	*Oct*	*Oct*	*Oct*	*Oct*	*Oct*	*Oct*

resources: LA452 notes, http://www.mobot.org, UI Plants Database, Pollenlibrary.com

Table 6 a. Perennial Selection Chart (*page 1*).

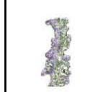
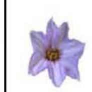
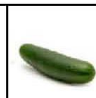
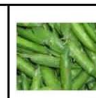
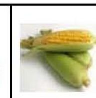
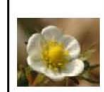
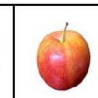
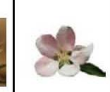
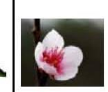
													**bloom image**
Liatris spicata	*Mertenoia virginica*	*Coreopsis grandiflora*	*Iris fulva*	*Paeonia tenuifolia*	*Viola sororia*	*Aquilegia canadensis*	*Tradescantia virginiana*	*Caltha palustris*	*Geranium maculatum*	*Wisteria frutescens*	*Crocus vernus*	*Vinca minor*	***scientific***
Blazing Star	Virginia Blue Bells	Coreopsis	Copper Iris	Peony	Wooly Blue Violet	Wild Columbine	Spiderworts	Marsh Marigold	Cranesbill	American Wisteria	Crocus	Common Periwinkle	**common**
2-4'	14"-20"	2-3'	2-3'	1-2'	.5-.75'	2-3'	1-2'	1-2'	1.5-2'	15-30'	6"-12"	3"-6"	**height**
.75-1.5'	1-2'	1.5'	1-2'	.75-1.5'	.5-.75'	2'	1-1.5'	1-1.5'	1.5-2'	4-8'	6"-12"	creeping	**spread**
sun to part shade	part shade to shade	full sun	full sun to part shade	full sun to part shade	full sun to part shade	full sun	full sun to shade	full sun to part shade	part sun to shade	full sun	full sun to shade	full sun to shade	**sun**
moist to wet	moist	dry to medium	medium to wet	medium	medium	well drained	moist	wet	wet spring dry summer	medium	well drained	medium	**water**
March April May **June** **July** Aug Sept Oct	March April **May** **June** **July** **Aug** Sept Oct	March April **May** **June** **July** **Aug** Sept Oct	March April **May** **June** July Aug Sept Oct	March April **May** June July Aug Sept Oct	March **April** **May** **June** **July** **Aug** Sept Oct	March **April** **May** **June** **July** Aug Sept Oct	March **April** **May** **June** **July** Aug Sept Oct	March **April** **May** **June** July Aug Sept Oct	March **April** **May** **June** July Aug Sept Oct	March **April** **May** June July Aug Sept Oct	**March** **April** **May** June July Aug Sept Oct	**March** **April** May June July Aug Sept Oct	**bloom times**

Table 6 b. Perennial Selection Chart (*page 2*)

bloom image											
scientific	*Lobelia cardinalis*	*Sedum 'autumn joy'*	*Aster novaeangliae*	*Symphyo-trichum ericoides*	*Passiflora incarnata*	*Eupatorium purpureum*	*Helianthus hirsusstus*	*Solidago speciosa*	*Rudbeckia fulgida*	*Asclepias syriaca*	*Rudbeckia laciniata*
common	Cardinal Flower	Stonecrop	New England Aster	Heath Aster	Wild Passion Flower	Joe Pye Weed	Hairy Sunflower	showy goldenrod	Black-Eyed Susan	Common Milkweed	Cutleaf Coneflower
height	2-5'	2'	1-4'	6"-36"	6-8'	5-7'	48"-60"	12"-72"	2-3'	2-3'	2-10'
spread	1-2'	1.5-2'	1-4'	1-1.5'	3-6'	2-4'	3'	2-3'	2-2.5'	.75 - 1'	1.5-3'
sun	full sun to part shade	full sun	full sun to part sun	sun to part shade	full sun to part shade	full sun to part shade	full sun to part shade	full sun to shade	full sun	full sun	full sun to part shade
water	moist to wet	dry to medium	moist	moist to wet	medium well drained	medium to wet	moist to wet	moist to dry	dry to medium	dry to medium	moist to dry
bloom times	March April May June July **Aug Sept Oct**	March April May June July **Aug Sept Oct**	March April May June July **Aug Sept Oct**	March April May June July **Aug Sept Oct**	March April May June **July Aug Sept** Oct	March April May June **July Aug Sept** Oct	March April May June **July Aug Sept** Oct	March April May **June July Aug Sept Oct**	March April May **June July Aug Sept** Oct	April May **June July Aug** Sept Oct	March April May **June July Aug** Sept Oct

resources: LA452 notes, http://www.mobot.org, http://www.illinoiswildflowers.info

Table 7. Crop and Herb Selection Chart.

Produce image	bloom image	scientific	common	height	spread	sun	water	bloom times
		*Curcurbita maxima*	Pumpkin	1-2	10-20	full sun	medium	Aug, Sept, Oct
		*Perovskia atriplicifolia*	Azure Sage	3-5	2-3	full sun o partial shade	medium	July, Aug, Sept, Oct
		*Curcurbita pepo*	Zucchini	2-3	3-4	full sun	moist well drained	June, July, Aug, Sept, Oct
		*Solanum melongena*	Eggplant	1-4	1-2	full sun	moist well drained	June, July, Aug, Sept, Oct
		*Cucumis sativus*	Cucumbers	1-1.5	12	full sun	wet well drained	June, July, Aug, Sept, Oct
		*Solanum lycopersicum*	Tomato	6-8	1.5-3	full sun	wet well drained	June, July, Aug, Sept, Oct
		*Pisum sativum*	Sugar Snap Peas	4-6	.5	full sun	medium	June, July, Aug, Sept
		*Lavandula angustifolia*	Lavendar	1-3	1-3	full sun	moist well drained	June, July
		*Rheum rhabarbarum*	rhubarb	1-3	1-4	full sun	medium	May, June, July, Aug
		*Zea mays L var rugosa*	Sweet Corn	6-8	12	full sun	wet well drained	May, June, July
		*Fragaria ssp*	Strawberries	.5	1.5	full sun	well drained	May
		*Malus domestica*	Apple	6-40	6-20	full sun	well drained	April
		*Prunus perscia*	Peach	6-20	6-20	full sun	medium	March

resources: UI Extension Office, theessentialgardenguide.com, www.bhg.com,daytonnursery.com

CHAPTER 8

CREATING NEIGHBORHOOD HABITAT ZONES

> The city, the suburbs, and the countryside must be viewed as a single, evolving system within nature, as must every individual park and building within the larger whole.
>
> --Anne Whiston Spirn, Granite Garden

Government initiatives and corporations have made attempts at improving the environment but it will take a broader commitment to make real progress toward sustainability. There must be initiatives that reach out to the grass-roots level focusing on education, individual choices, and individual aesthetics to make sustainable landscapes culturally accepted and supported (Hunter, 2011). By focusing on eight-acre building blocks, an individual can organize his or her own area within the metropolitan built space and utilize what is already growing. An individual may work alone or be the catalyst for neighborhood groups to work on making a coordinated difference.

Scale details

The Neighborhood scale of eight acres is roughly equivalent to a circle with a 660-foot diameter, or a circle with a diameter the length of about two American football fields. The average suburban lot is ¼ acre so the neighborhood habitat zone would incorporate approximately 32 lots (Mason, 2010). These circular areas are, on average, 40% vegetation. If even half of that space is planted with vegetation to support honey bees through the three foraging seasons, using the apiarist rule of thumb of 1 hive per acre, then each neighborhood scale space could support approximately 1 ½ hives as well as the native pollinators. These statistics would have to be adjusted to fit the actual neighborhood. Parks, balconies and rooftops could also be incorporated into the model

Figure 27. Neighborhood Spaces. The average suburban lot is ¼ acre so the neighborhood habitat zone would incorporate approximately 32 lots (Mason, 2010). These circular areas on average contain 40% vegetation. This potential bee habitat is an untapped resource. Underlay photo - *St. Louis, Missouri (Google Maps, 2008)*

depending on the area. This level is designed to provide information for one person to be able to make a difference alone, even though the greater the number of individuals involved the greater the impact. The ultimate goal is to make every yard and open area bee-friendly. Since honey bees will travel where they need to for forage, even one yard can make a difference.

Needs Assessment

Bees must have a variety of pollen (to provide protein) and nectar (to provide carbohydrates) available to them throughout the foraging

Figure 28. Yard with virtually no habitat for honey bees. Many residential yards are sculpted into being visually appealing but are nutritionally sterile. The turf takes a lot of care and often large amounts of pesticides in order to be maintained, the other plants are too small, not providing enough quantity to attract pollinators.

season and in quantities that support the hive development (Somerville, 2005). A single tulip will not attract the hive because there is simply not enough forage. There needs to be a larger array of tulip beds blooming, but in a neighborhood that does not mean all of the tulips have to be in the same yard; there can be a combination of resources. This analysis tool may be used by a group of people in a neighborhood,

Figure 29. Yard with an abundance of habitat for honey bees. By changing and adding a few items this residential yard becomes a destination for honey bees foraging for pollen and nectar. Some turf remains for the use of the homeowner but much has been replaced by blooming plants which should take less gas and electricity to maintain, less pesticides and once the plants are established should take less water as well.

or one individual may inventory the neighborhood on his or her own. The analysis of a neighborhood is not static and will continue to change as people continue to add new plants and as the life cycle of vegetation advances. Focusing on those items that bloom perennially will increase habitat stability. Like most environmental changes this is not a one-time issue - it is a call for a change in paradigm where long-term planning is encouraged and supported.

Communication

There are many suggestions for disseminating this information locally, such as garden clubs and science centers. Information could be provided by nurseries and garden stores who could not only distribute the information to the public but also help to make sure that plant materials are available. To aid in the communication of this information a brochure focusing on the "eight-acre building block" has been developed [see appendix]. This brochure outlines space needs, food requirements, and pesticide use. It also makes the suggested plant list and the inventory sheet available. The current brochure is zone 5 specific but other zones plant lists could be developed.

Limitations

In many ways this issue, as it is presented to garden owners, is oversimplified, giving them only the very basic information needed to make a difference within their own spaces. More complex information is available through other outlets and opportunities. The design of this project is to craft a first step in making basic information available to a wide audience. This step is designed to be a relatively easy one, creating a starting point for conversation and making a case for taking larger steps. The neighborhood plan for habitat development is not intended as an end-all and will not save honey bees by itself. There must be a broader understanding of honey bee requirements and habitat limitations. This guide is designed to initiate relatively simple grass root steps that an individual can adopt to increase bee habitat development and sustainability.

This project has neglected pollinators such as native ground bees as well as other insects and other wildlife. Many of these organisms will be assisted by honey bee habitat development but there are also needs not currently addressed through the habitat design suggested here. Additional site-specific research would need to be conducted to design native bee habitats. There are thousands of native bee species, each having specific requirements for nesting and foraging (Marlin, 2009, personal communication).

CHAPTER 9

CREATING METROPOLITAN HABITAT ZONES

> Like winds and sunsets, wild things were taken
> for granted until progress began to do away with
> them. Now we face the question whether a still
> higher 'standard of living' is worth its cost
> in things natural, wild and free.
>
> --Aldo Leopold, A Sand County Almanac

SCALE DETAILS

In the metropolitan 'habitat zone creation process' the basic building block of eight acres is used but with the knowledge that eight acres represents a single building block within an Urban Development plan. These building blocks are coordinated and managed as a city-wide effort creating an even greater safe zone for the bees. The eight-acre scale size is based on human walking distances; the metropolitan scale relies more heavily on honey bee flying distances.

Honey bee scouts will travel a radial distance of approximately two miles from the hive no matter how close ample supplies of nectar and pollen may be found (Winston, 1991). The foraging workers concentrate on the highest quality and closest resources as determined by these scout bees. This behavior ensures the hive will have sufficient daily foraging areas as old patches give out or are destroyed (Winston, 1991). Using this minimal scout distance as the base of the area a two-mile building block (TMBB) was developed for larger metropolitan areas.

These building blocks are a way to arrange space within a city to make sure each district or community within the city is able to support bee habitat. Zones may overlap, or a circle may develop into a polygon to reach every segment of the greater metropolitan area. The eight-acre building block (EABB) is a way of dividing the city into small, manageable chunks, so that as change is being organized a coordinated choice of blooming plants and the temporal availability is not overlooked. The TMBB is utilized to organize the effort on a larger scope. City planners and apiarists can view the city in these two-mile chunks to insure that all of the EABBs are coordinated and that there are not areas within the city that may be poisoning or otherwise harming the bee population. I believe this multi-block approach has a great deal more to offer the health of a city than the neighborhood single block. Organizing districts to utilize open spaces and develop street and park plantings in habitat- friendly ways such as group plantings, buffer plantings and rain garden plantings ensures that the

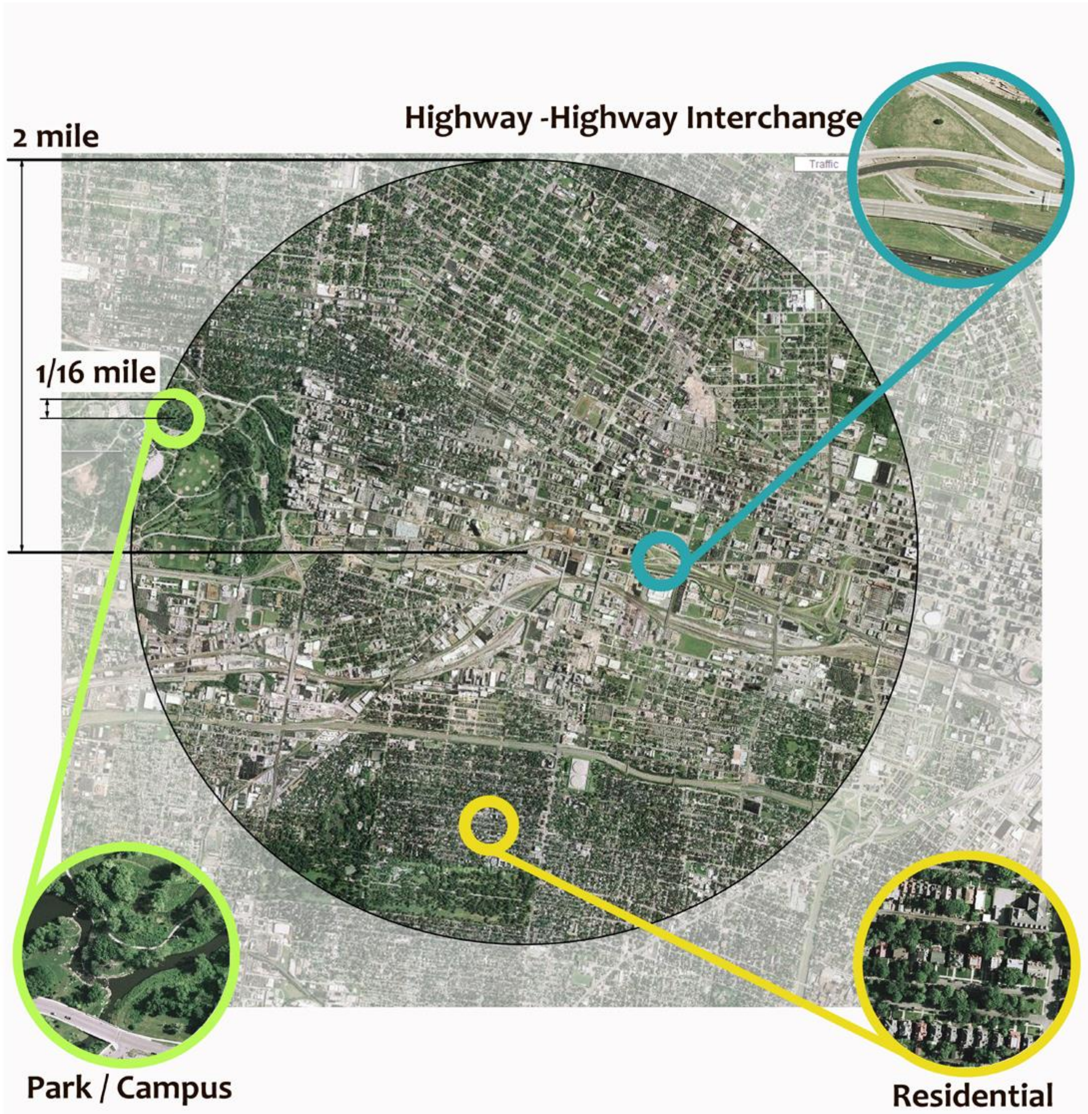


Figure 30. Eight Acre Building Blocks. Within a metropolitan area there are many neighborhoods and multifunctional districts. Dividing the metropolitan area into eight acre building blocks creates manageable chunks so that change can be managed and coordinated. This multi-block approach utilizes the neighborhood single block methods but by linking them together the effort can then be coordinated making a difference on a larger scale. *Underlay photo - St Louis, Missouri (Google Maps, 2008)*

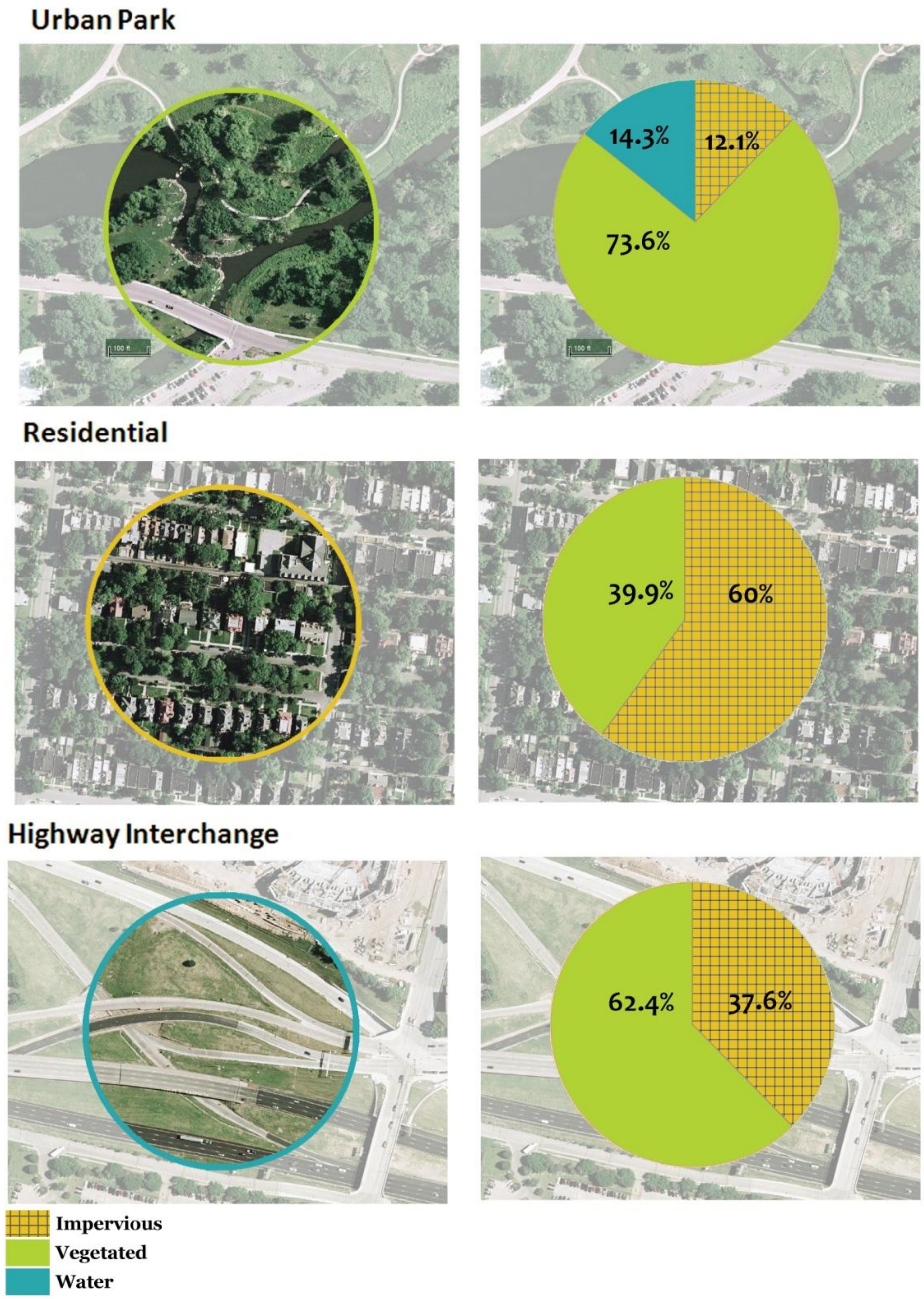


Figure 31. Opportunities 8 Acres at a Time. The amount of potential bee forage in a metropolitan area is significant. Even in areas that may be considered urban waste (unused land) such as highway interchanges, there are considerable opportunities to aid habitat, enhance the aesthetic and create more sustainable landscapes within the urban-suburban environment. *Underlay photo - St. Louis, Missouri (Google Maps, 2008)*

entire ecological community benefits. More honey production will be supported, more carbon may be sequestered and rain water may be diverted to planted areas for use on-site instead of whisking all of it away in the storm sewer systems. The habitats for many organisms living within cities in addition to bees may be supported.

Needs

Parks, campuses, and golf courses are open spaces that readily provide reduction of the heat island effect and often address hydrological issues. However, where the area of built habitat dominates the landscape, form and plant color are often the main deciding factors. If habitat issues could address selection of plant materials and pesticide use decisions added to those considerations, then large areas of bee habitat could be developed with relative ease. By linking these opportunities even areas as small as walkway hanging baskets, curbside planters, green wall systems or green roofs could be utilized to support habitat as well as contribute to the larger connected efforts.

Limitations

The limits of the Neighborhood apply to this scale also but there are additional limits at a larger metropolitan scale. In conversations about creating habitats, people's fears, myths and biases surface. A metropolitan area is ruled by a community of people from across socio-economic areas, political ideologies and aesthetics. When we mention "native species" some individuals cannot get past the concept of weeds (Kimber, 2004; Weigert, 1994). Native plant cultivars have been developed to have shorter and denser growth patterns so every yard does not have to have the appearance of a prairie restoration. Misconceptions of plants and their connection to allergies are also a hurdle. Nectar- and pollen-rich plants that need insect pollinators are not generally the worst for allergens. Wind and self-pollinating plants have larger quantities of smaller-grained pollen (Sheppard, Buchmann, Vaughan, and Hoffman Black, 2003) and thus are far worse for allergen production, so these plants should be avoided where allergies are a factor.

The fear of bees is also an issue. Even though most pollinators are very nonaggressive away from their home sites, stinging carnivorous insects such as hornets and a variety of wasps mimic the appearance of bees. These aggressive species have created fear responses to all species with stinging abilities (Kellert, 1993). The issue of community fears and assumptions must be addressed: education and information are the best defense.

Communication

Developing a manual that focuses on habitat issues to inform nursery managers, planners and designers will aid in the education process. New development that balances public and private green space within metropolitan areas is happening. Chicago is just one city that has made strides in these areas and, due to recognition and rewards to businesses and individuals, a great deal is continuing to occur (Henry, 2009). This is a good model and provides hope that a difference can be made but even Chicago could do more with regard to ecological systems and habitat development.

CHAPTER 10

CONNECTING HABITAT ZONES AND OTHER FUTURE POSSIBILITIES

> Humankind has not woven the web of life.
> We are but one thread within it.
> Whatever we do to the web, we do to ourselves.
> All things are bound together. All things are connected.
>
> --Chief Seattle

The possibilities to continue this work are virtually unlimited. It is my hope that others reading this thesis are inspired to not only take action

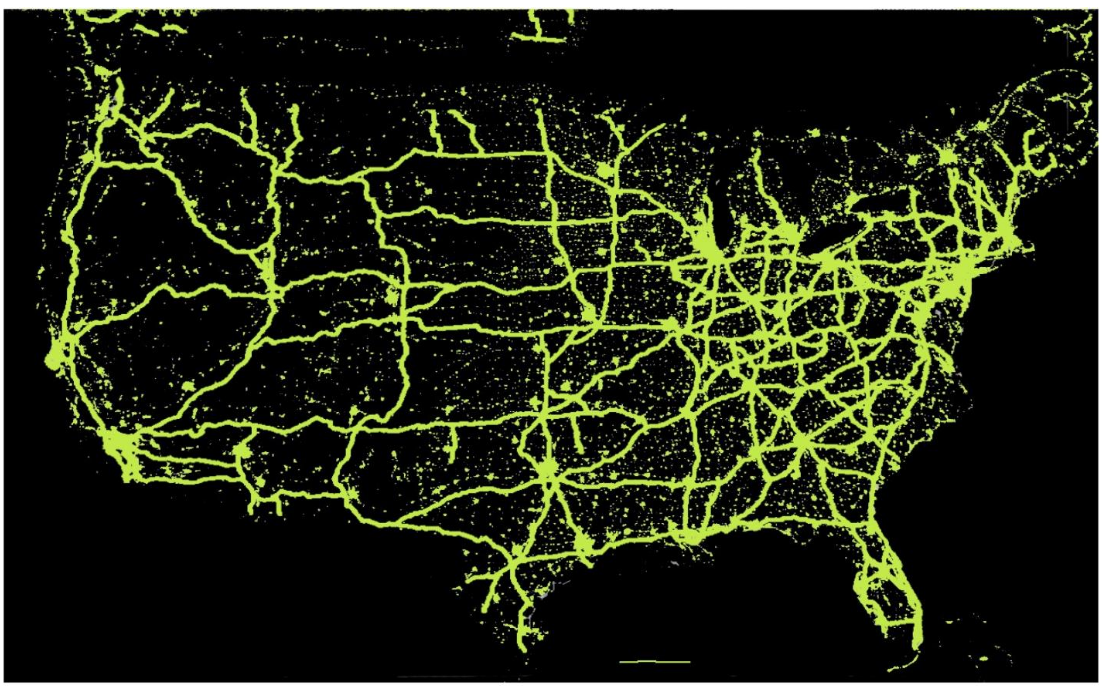


Figure 32. Habitats within Cities and linked by Highway Corridors. The potential for growth of this system is virtually unlimited. Each eight-acre neighborhood gets connected to another to form metropolitan zones and each of these zones could be linked by highway corridors. These corridors are highly mowed yet wasted networks of spaces. *Original map images (*NASA Earth Observatory/NOAA NGDC, 2010)*; (*U.S. Department of Transportation, Maritime Administration, 2010).

but to conduct additional research. The next step is to create plant lists for all temperate zones within the United States. This will widen the scope and reach of this project. The second focus will be developing guidelines to connect these metropolitan habitat zones by limiting pesticide use and planting pollen- and nectar-rich plants along highway rights-of-way that will create greater habitat opportunities. For instance, the French Highway Administration is sowing nectar-rich seeds along highways to create bee habitat (Black, 2010), and in Finland the total of their managed roadside habitat is seven times greater than the area remaining in grassland (Hunter and Hunter, 2008). Other countries are using these areas as opportunities to assist habitat support; the United States with its vast highway system is missing out.

Planting vegetation that supports pollinators along the highway rights-of-way could use the resources already allotted to these large expanses in more sustainable ways. Planting these corridors would reduce erosion and flooding but also may mean additional sustainable habitat support with less mowing. There were 157,724 miles of highway networked across the United States in 2011 and each side of the right-of-way averages between 150 and 300 feet (FHWA, 2012). The conservative potential would be for 47,317,200 square miles of habitat that could be created. This effort may continue by placing hives under creek bridges or creating bee "rest" stops throughout the United States to give over-the-road beekeepers a place to supplement and diversify the bees' diets naturally.

The third opportunity would be to focus on the expanse of virtual desert in farmland. As mentioned previously, monoculture agriculture creates virtual deserts for bees for all but one month of the summer season. These areas are often large tracts of land with mowed drainage and border corridors. These unused spaces could act much like the highway rights-of-way.

There is also governmental support for this rural development of pollinator habitat. In 2011 the United States Department of Agriculture created CP-42, a conservation program to encourage and assist farmers in creating pollinator habitat on their land (United States, Department of Agriculture, 2011). This program outlines specifications for adequate land sizes and classifies flowering groups into three categories that ensures coverage throughout the foraging seasons (United States, Department of Agriculture, 2011). The planning guide provided in the Appendix of this thesis could be helpful in the development and adoption of the CP-42 program.

My main goal is for bee habitat to be integrated into the collective conscious of the United States culture by creating an environment where sustainability and the effects of human action on other species are taken into consideration as commonplace. Designing without ADA regulation in the past excluded large numbers of people from accessing daily needs and is now integrated into every aspect of design. It is unthinkable to plan without all users in mind. Habitat can become habit as designers continue to develop bridges between form versus function.

CHAPTER 11

CONCLUSION

Outside lies utterly ordinary space open
to any casual explorer willing
to find the extraordinary.
Outside lies unprogrammed awareness
that at times becomes directed serendipity.
Outside lies magic.

-- John Stilgoe, *Outside Lies Magic*

In reviewing ecological and human systems, particularly in urbanized areas, there are many issues that must be considered and addressed. The current *modus operandi* of urban development is not sustainable and has led to many problems in urban areas (Ahem, 2006). A more comprehensive way to think about systems and the way they function on living sites, yards and open areas must be cultivated. New techniques to access necessary information must be developed to give designers and land owners more insight and information to jump start the creative process.

The main purpose of this research was to determine the ecological needs required to sustain honey bee populations, and to use this knowledge to integrate the human and insect needs to create a methodology to develop integrated habitat design for honey bees in the Midwest. Focusing on one of the smallest creatures in the system and analyzing its needs and then combining that information with human aspects of land development, a system has been developed to aid in the planning and design of urban areas. This development plan is not intended to stop CCD in urban areas but to diversify the habitat. If urban beekeepers work on building a healthier base of hives it will give scientists more time to discover the underlying problems and to develop the steps to remedy these issues. Due to the divergent directions and the magnitude of distance that honey bees fly, beekeepers cannot accomplish this goal alone. Honey bees can only be as healthy as the community where they forage. If the community is made of little flowering material or if pesticides are used without concern for beneficial insects, then the hive cannot survive. Humans have tipped the balance of the environment and must now adjust to find a new balance in an ever-changing habitat.

The ultimate goal of designers must be to aid and support all living things within the urban environment: honey bees, native bees, birds, squirrels, humans and most importantly the plants that will exist in these spaces. By creating a methodology to assist in the development of healthier living environments for the honey bee, species all across the food web will reap environmental benefits.

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APPENDIX

NEIGHBORHOOD BROCHURE ZONE 5

A multipage brochure was created to disseminate the information researched in this thesis to a broader audience.

FIGURE 33. COVER PAGE. *Trisha Hurst 2016*

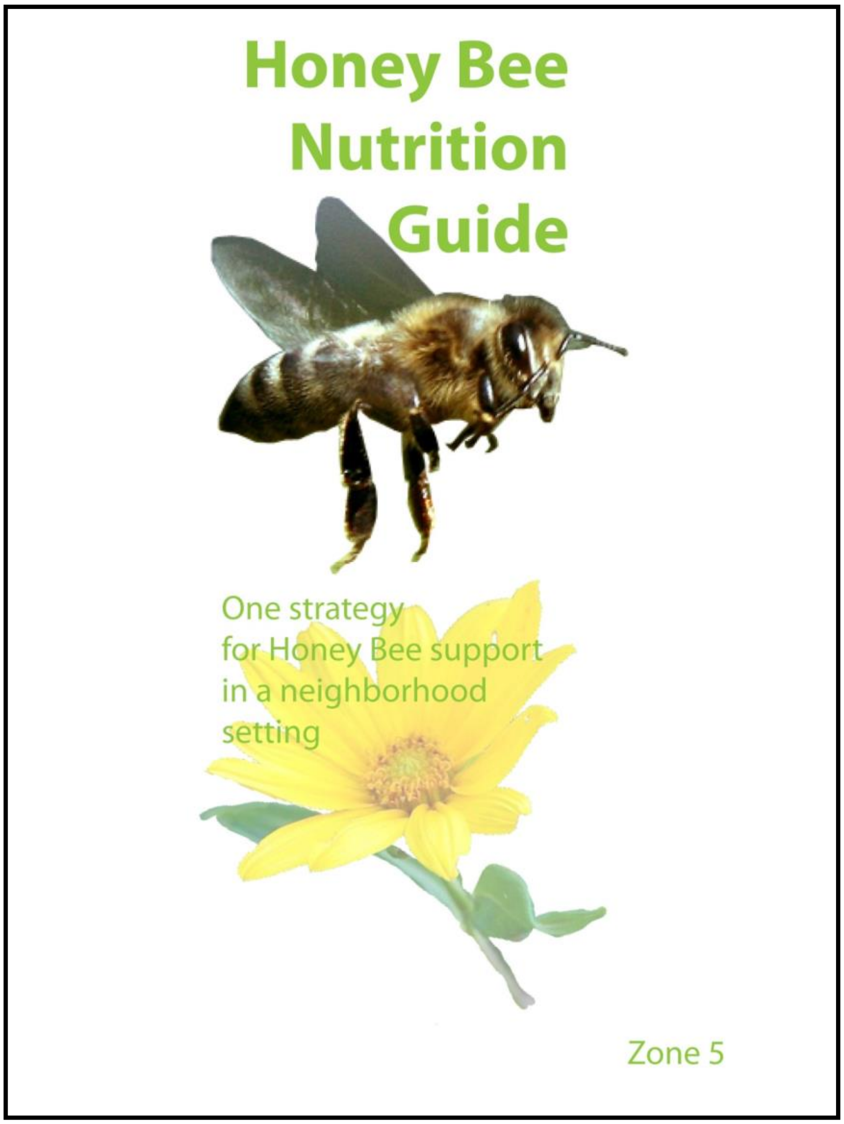


FIGURE 34. PAGE 1. *Trisha Hurst 2016*

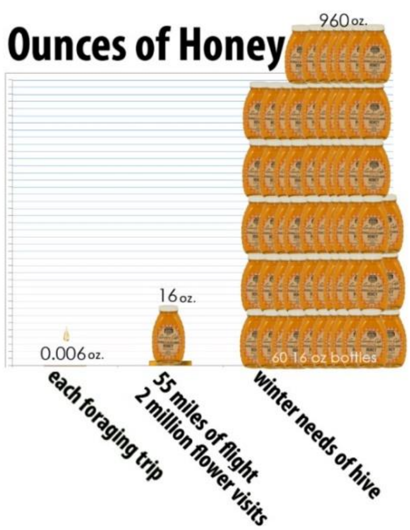
Honey Bee Facts:

Honey bees are at a critical point in their existence. There are different mites, predators, honey thieves and diseases that has existed for years but over the last three years a health issue has arisen that have devastated hives. This epidemic is called CCD or colony collapse disorder and has spread worldwide. Bee keepers find their hives, missing the large majority of worker bees. Tens of thousands of adult worker bees just seem to vanish leaving the queen and juvenile bees in the hive with the honey. Previous to CCD starvation and malnutrition had been leading causes of over wintering losses and according to some research may contribute, along with other stressors, to losses due to CCD.

This brochure is one attempt to limit the stress of foraging on bees, including making sure pollen and nectar are available throughout the growing season, one neighborhood at a time.

This will make the bees healthier and more productive, creating the effect of healthier living environments for people as well as birds, animals and other insects in the neighborhood.

To coordinate a workable space a human scale space was overlaid onto a bee scale space. According to recent research the average American is willing to walk to a destination that is ¼ of a mile away or ½ mile round trip. (APA, 2006) Applying this knowledge to create a neighborhood scale a 1/16 mi radius circle selected. The perimeter of this neighborhood unit would be 1/3 of a mile with an 1/8 of a mile to get to and from the edge equals about ½ mile. The rule of thumb for apiarist is 1 acre of foraging material per hive. (Flottum, 2010)



This neighborhood scale equals 8 acres in total space, a minimum of 1 acre could easily be utilized to support honey bees through the three foraging seasons if it were planted and managed appropriately.

The Neighborhood scale eight acre area is roughly equivalent to a circle with a 333 foot radius,

FIGURE 35. PAGE 2. *Trisha Hurst 2016*

or a circle with a radius the length of about an American football field. The average suburban lot is ¼ acre so the neighborhood habitat zone would incorporate approximately 32 lots. (Mason, 2010) This number would need to be adjusted to fit the actual neighborhood, considering parks, balconies and rooftops could also be incorporated into the model in more densely populated areas. The ultimate goal is to have every yard and open area be bee friendly. Honey bees will travel to where forage is available so even one yard can make a difference. This level is designed to provide information for one person to be able to do this alone, even though the greater the number of participants, the greater the impact.

The first step is to find the blooming times for plants within an approximately 8 acre space. Bees and other pollinators need a variety of nectar and pollen producing plants throughout the three season foraging period. In the center of this booklet a circle chart has been provided. This record will aid in knowing what is available for the bees in any given month and will reveal if there are any times that need to be addressed. There is an example form below. Write the name or descriptor of each plant, document the number of flowers (S, M, or L can be used for amounts). Bees prefer larger plantings of flowers over variety at a given time.
Double-flowered varieties should not be counted unless researched; many modern cultivars have been developed without pollen.

While the analysis is progressing and as thin times for foraging materials emerge, the charts on the following pages may be useful tools in finding additional plants that honey bees may prefer. A single tulip will not attract the hive because there is simply not enough to forage. There needs to be a larger array of tulip beds blooming, but in a neighborhood that does not mean all of the tulips have to be in the same yard, there can be coordination of resources. By utilizing the analysis tool circles may be coordinated through a neighborhood group, or one person may walk around and assess the neighborhood on their own. The analysis of a neighborhood is not static and will continue to change as people continue to plant new things and as the life cycle of vegetation advances but in focusing on those items that bloom perennially stability may be increased. Like most environmental changes this is not a one time issue it calls for a change in paradigm.

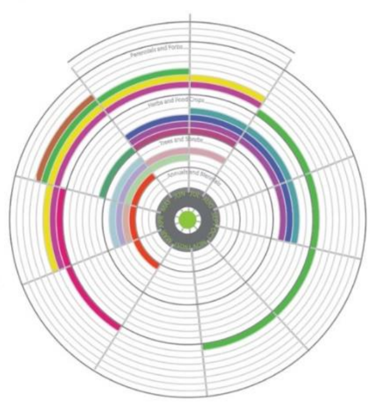
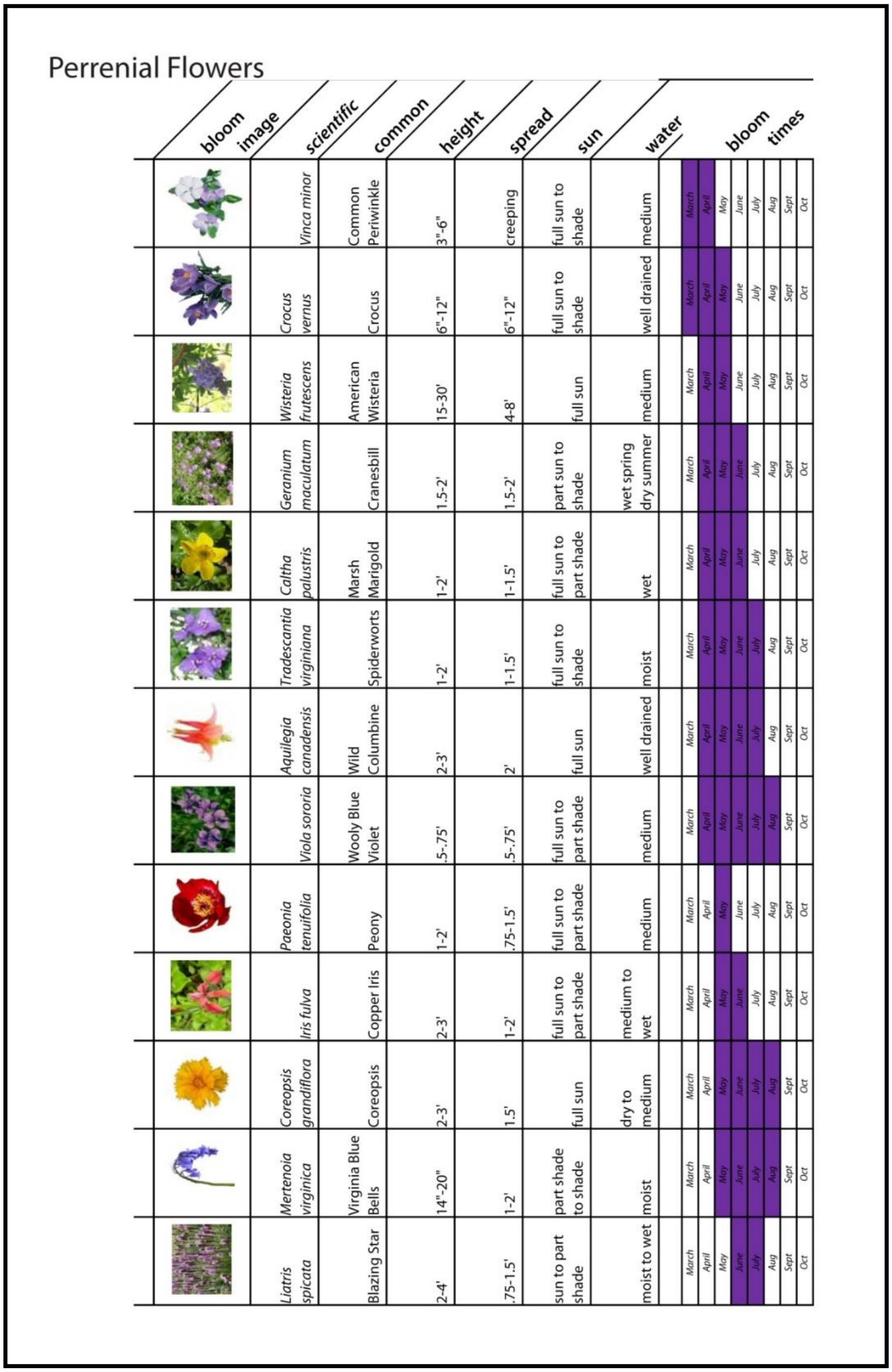


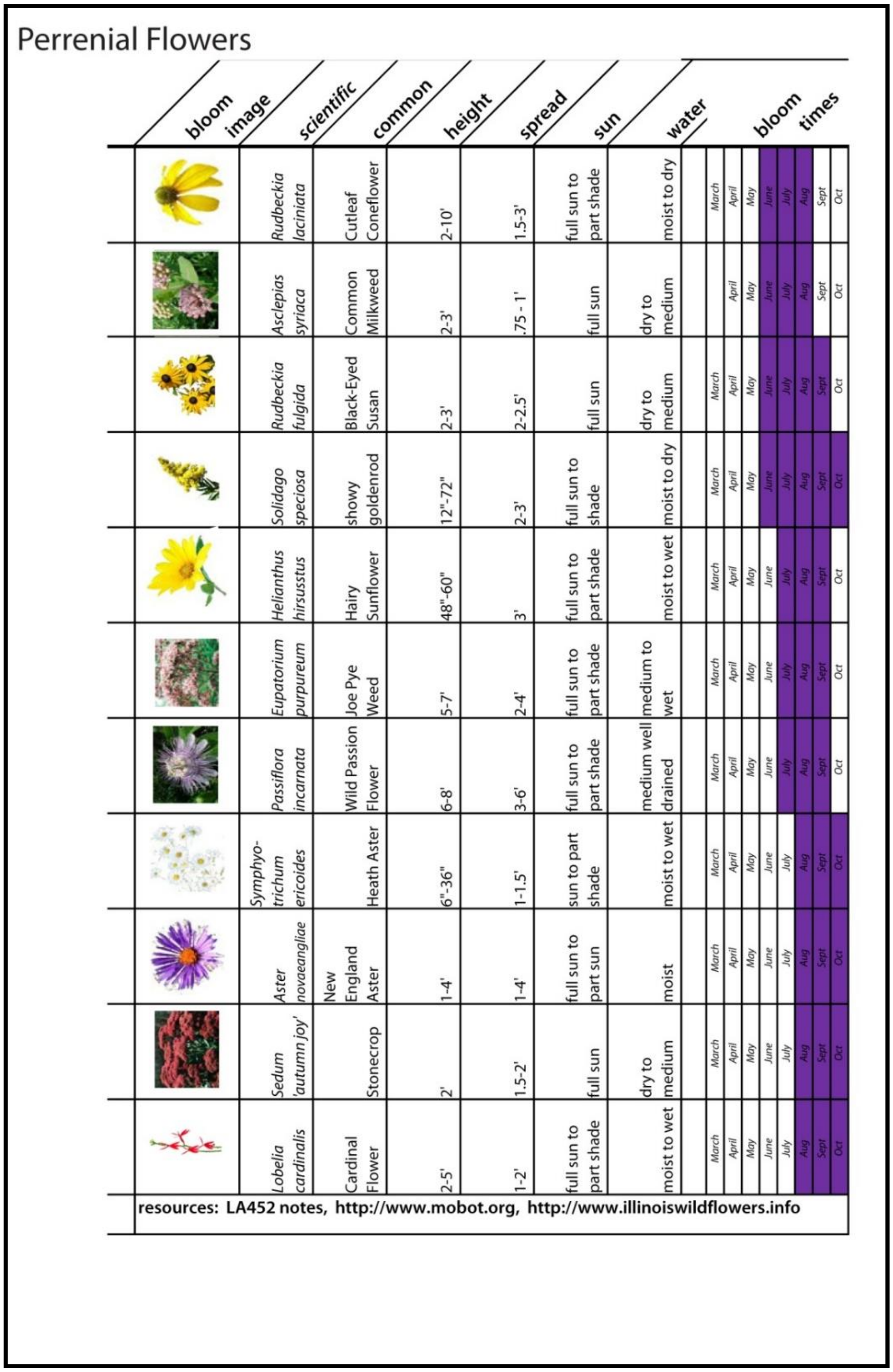
FIGURE 36. PAGE 3. *Trisha Hurst 2016*



Perrenial Flowers

bloom image	scientific	common	height	spread	sun	water	bloom times
	Vinca minor	Common Periwinkle	3"-6"	creeping	full sun to shade	medium	March, April
	Crocus vernus	Crocus	6"-12"	6"-12"	full sun to shade	well drained	March, April, May
	Wisteria frutescens	American Wisteria	15-30'	4-8'	full sun	medium	April, May
	Geranium maculatum	Cranesbill	1.5-2'	1.5-2'	part sun to shade	wet spring dry summer	April, May, June
	Caltha palustris	Marsh Marigold	1-2'	1-1.5'	full sun to part shade	wet	April, May, June
	Tradescantia virginiana	Spiderworts	1-2'	1-1.5'	full sun to shade	moist	April, May, June, July
	Aquilegia canadensis	Wild Columbine	2-3'	2'	full sun	well drained	April, May, June, July
	Viola sororia	Wooly Blue Violet	.5-.75'	.5-.75'	full sun to part shade	medium	April, May, June, July, Aug
	Paeonia tenuifolia	Peony	1-2'	.75-1.5'	full sun to part shade	medium	May
	Iris fulva	Copper Iris	2-3'	1-2'	full sun to part shade	medium to wet	May, June
	Coreopsis grandiflora	Coreopsis	2-3'	1.5'	full sun	dry to medium	May, June, July, Aug
	Mertenoia virginica	Virginia Blue Bells	14"-20"	1-2'	part shade to shade	moist	May, June, July, Aug
	Liatris spicata	Blazing Star	2-4'	.75-1.5'	sun to part shade	moist to wet	June, July

FIGURE 37. PAGE 4. *Trisha Hurst 2016*

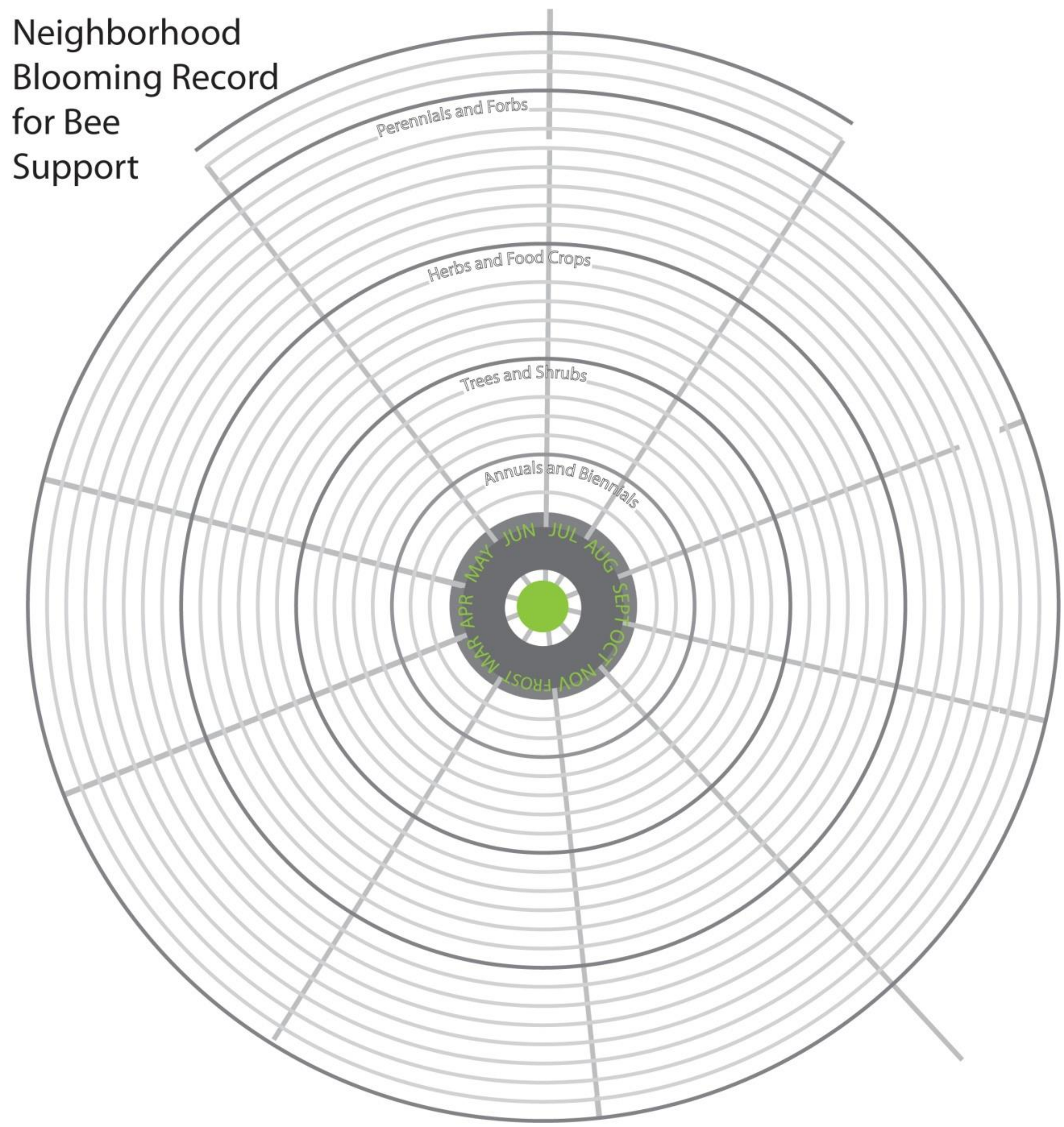


Perrenial Flowers

bloom image	scientific	common	height	spread	sun	water	bloom times
	Rudbeckia laciniata	Cutleaf Coneflower	2-10'	1.5-3'	full sun to part shade	moist to dry	June, July, Aug
	Asclepias syriaca	Common Milkweed	2-3'	.75 - 1'	full sun	dry to medium	June, July, Aug
	Rudbeckia fulgida	Black-Eyed Susan	2-3'	2-2.5'	full sun	dry to medium	June, July, Aug, Sept
	Solidago speciosa	showy goldenrod	12"-72"	2-3'	full sun to shade	moist to dry	June, July, Aug, Sept, Oct
	Helianthus hirsusstus	Hairy Sunflower	48"-60"	3'	full sun to part shade	moist to wet	July, Aug, Sept
	Eupatorium purpureum	Joe Pye Weed	5-7'	2-4'	full sun to part shade	medium to wet	July, Aug, Sept
	Passiflora incarnata	Wild Passion Flower	6-8'	3-6'	full sun to part shade	medium well drained	July, Aug, Sept
	Symphyo-trichum ericoides	Heath Aster	6"-36"	1-1.5'	sun to part shade	moist to wet	Aug, Sept, Oct
	Aster novaeangliae	New England Aster	1-4'	1-4'	full sun to part sun	moist	Aug, Sept, Oct
	Sedum 'autumn joy'	Stonecrop	2'	1.5-2'	full sun	dry to medium	Aug, Sept, Oct
	Lobelia cardinalis	Cardinal Flower	2-5'	1-2'	full sun to part shade	moist to wet	Aug, Sept, Oct

resources: LA452 notes, http://www.mobot.org, http://www.illinoiswildflowers.info

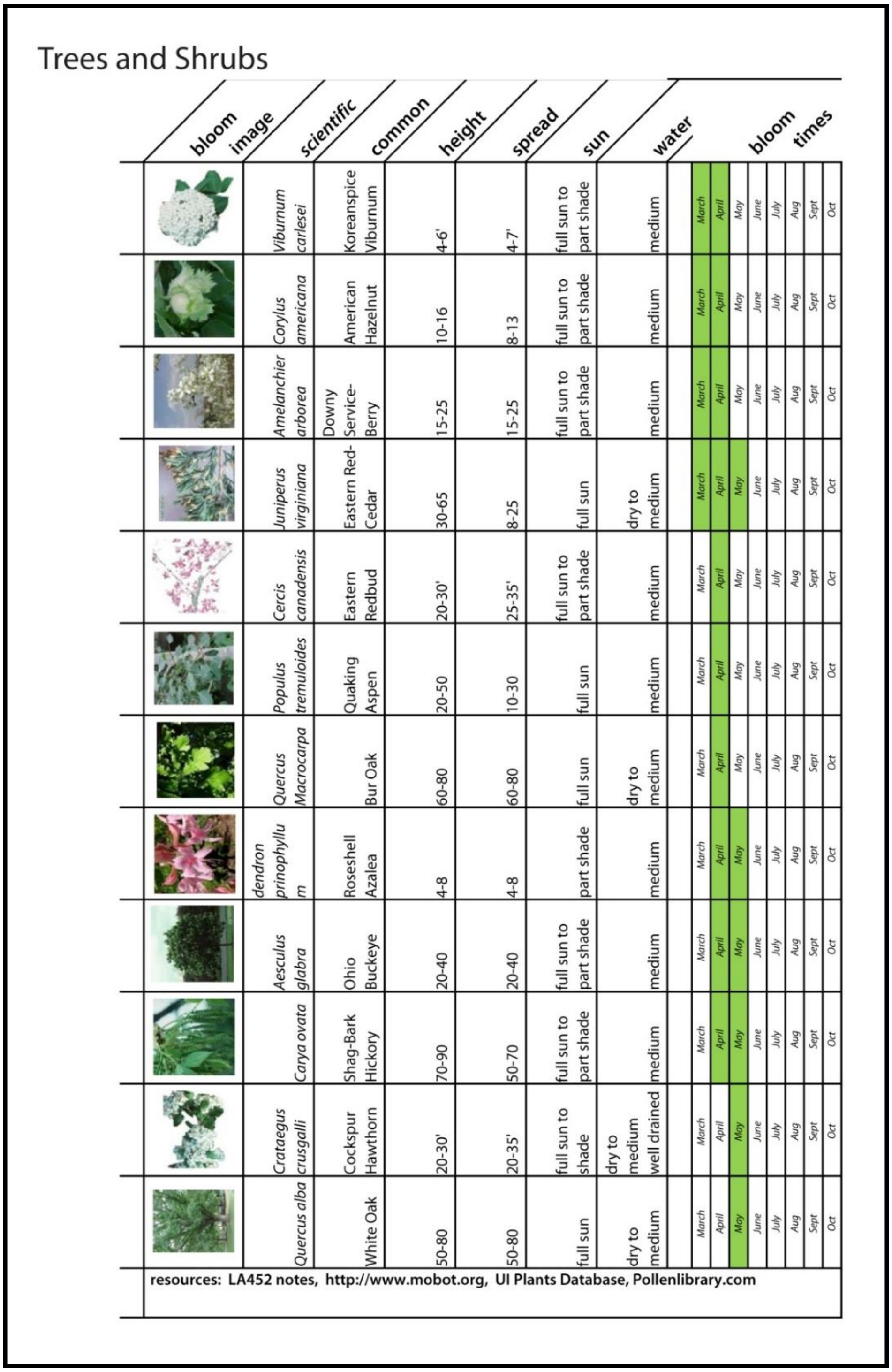
FIGURE 38. CENTER PAGES. *Trisha Hurst 2016*



Find the blooming times for plants within an approximately 8 acre space (a circle with a radius of about a football field or 32 suburban lots). Bees and other pollinators need a variety of nectar and pollen producing plants throughout the three season foraging period. This record has been created to aid in knowing what is available for the bees in any given month and will reveal if there are any thin times that need to be addressed. It is suggested to write the name or descriptor of each plant for future seasons referral and to document the number of flowers (S, M, or L can be used for amounts). Bees prefer larger plantings of flowers over variety at a given time.

Double-flowered varieties should not be counted unless researched (or pollinators seen visiting); many modern cultivars have been developed without pollen.

FIGURE 39. PAGE 7. *Trisha Hurst 2016*

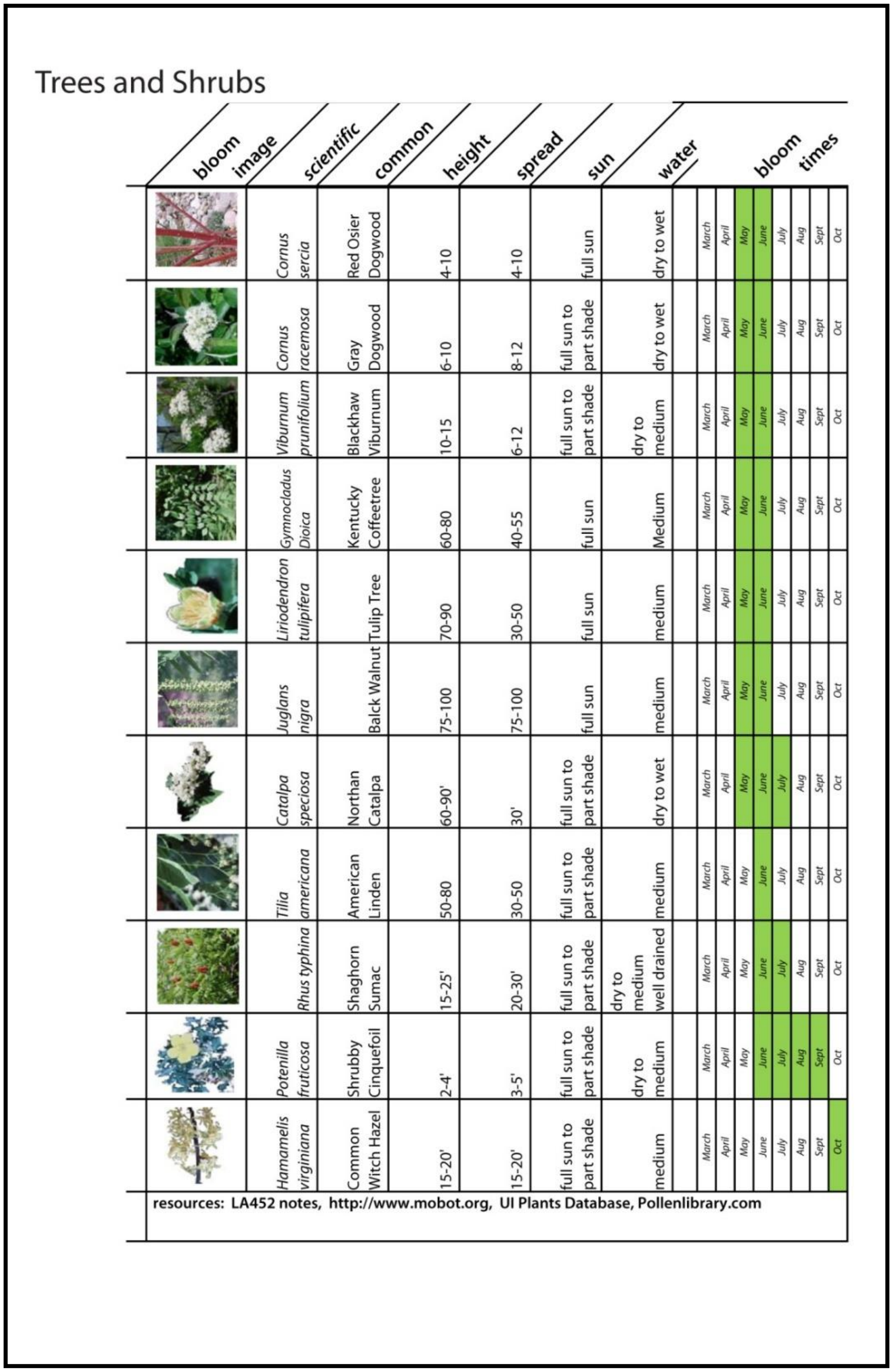


Trees and Shrubs

bloom image	scientific	common	height	spread	sun	water	bloom times
	Viburnum carlesei	Koreanspice Viburnum	4-6'	4-7'	full sun to part shade	medium	March, April
	Corylus americana	American Hazelnut	10-16	8-13	full sun to part shade	medium	March, April
	Amelanchier arborea	Downy Service-Berry	15-25	15-25	full sun to part shade	medium	March, April
	Juniperus virginiana	Eastern Red-Cedar	30-65	8-25	full sun	dry to medium	March, April, May
	Cercis canadensis	Eastern Redbud	20-30'	25-35'	full sun to part shade	medium	April
	Populus tremuloides	Quaking Aspen	20-50	10-30	full sun	medium	April
	Quercus Macrocarpa	Bur Oak	60-80	60-80	full sun	dry to medium	April
	dendron prinophyllum	Roseshell Azalea	4-8	4-8	part shade	medium	April, May
	Aesculus glabra	Ohio Buckeye	20-40	20-40	full sun to part shade	medium	April, May
	Carya ovata	Shag-Bark Hickory	70-90	50-70	full sun to part shade	medium	April, May
	Crataegus crusgalli	Cockspur Hawthorn	20-30'	20-35'	full sun to shade	dry to medium well drained	May
	Quercus alba	White Oak	50-80	50-80	full sun	dry to medium	May

resources: LA452 notes, http://www.mobot.org, UI Plants Database, Pollenlibrary.com

FIGURE 40. PAGE 8. *Trisha Hurst 2016*

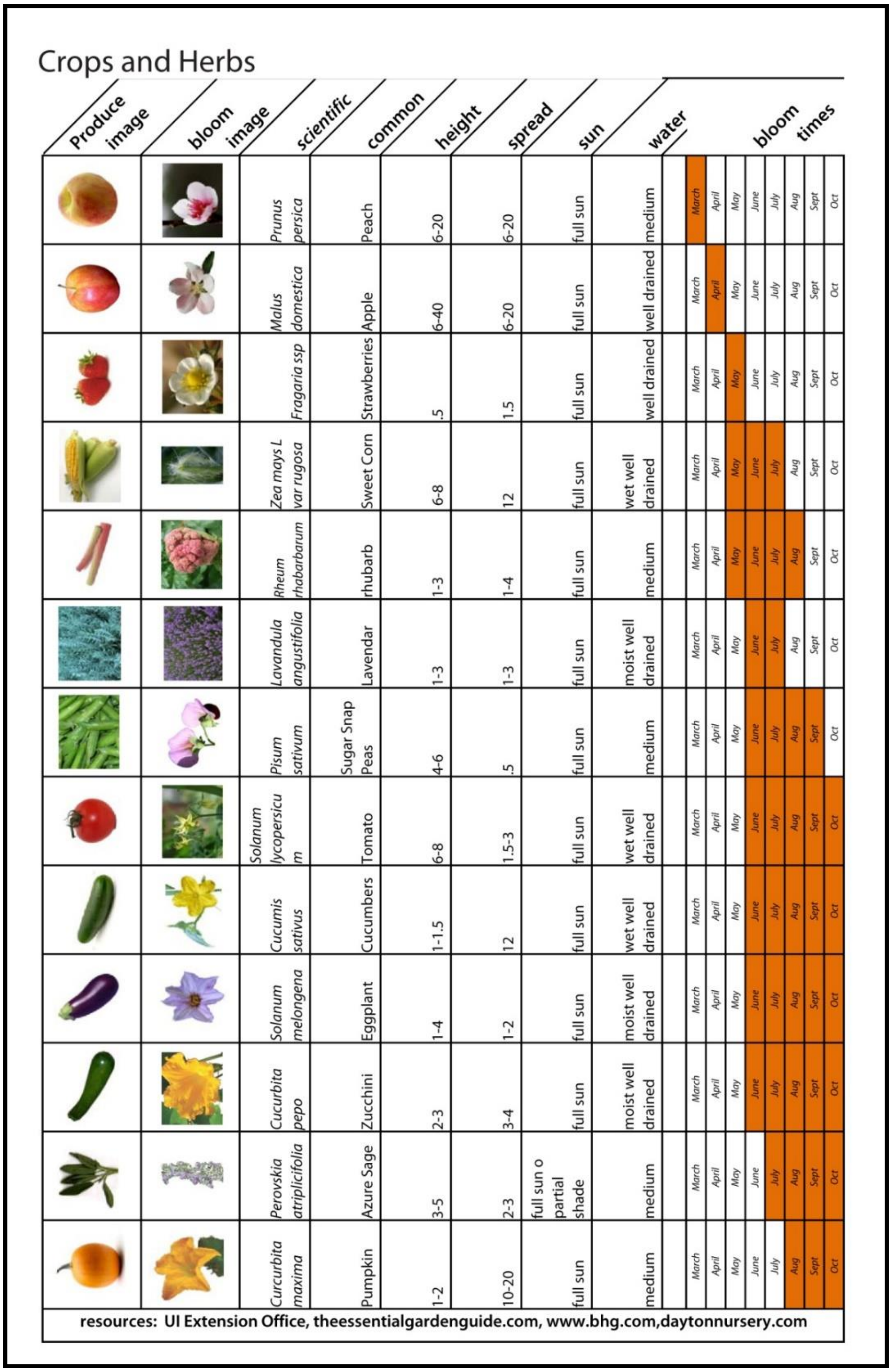


Trees and Shrubs

bloom image	scientific	common	height	spread	sun	water	bloom times
	Cornus sercia	Red Osier Dogwood	4-10	4-10	full sun	dry to wet	May, June
	Cornus racemosa	Gray Dogwood	6-10	8-12	full sun to part shade	dry to wet	May, June
	Viburnum prunifolium	Blackhaw Viburnum	10-15	6-12	full sun to part shade	dry to medium	May, June
	Gymnocladus Dioica	Kentucky Coffeetree	60-80	40-55	full sun	Medium	May, June
	Liriodendron tulipifera	Tulip Tree	70-90	30-50	full sun	medium	May, June
	Juglans nigra	Balck Walnut	75-100	75-100	full sun	medium	May, June
	Catalpa speciosa	Northan Catalpa	60-90'	30'	full sun to part shade	dry to wet	May, June, July
	Tilia americana	American Linden	50-80	30-50	full sun to part shade	medium	June
	Rhus typhina	Shaghorn Sumac	15-25'	20-30'	full sun to part shade	dry to medium well drained	June, July
	Potenilla fruticosa	Shrubby Cinquefoil	2-4'	3-5'	full sun to part shade	dry to medium	June, July, Aug, Sept
	Hamamelis virginiana	Common Witch Hazel	15-20'	15-20'	full sun to part shade	medium	Oct

resources: LA452 notes, http://www.mobot.org, UI Plants Database, Pollenlibrary.com

FIGURE 41. PAGE 9. *Trisha Hurst 2016*



Crops and Herbs

Produce image	bloom image	scientific	common	height	spread	sun	water	bloom times
		Prunus persica	Peach	6-20	6-20	full sun	medium	March
		Malus domestica	Apple	6-40	6-20	full sun	well drained	April
		Fragaria ssp	Strawberries	.5	1.5	full sun	well drained	May
		Zea mays L var rugosa	Sweet Corn	6-8	12	full sun	wet well drained	May, June, July
		Rheum rhabarbarum	rhubarb	1-3	1-4	full sun	medium	May, June, July, Aug
		Lavandula angustifolia	Lavendar	1-3	1-3	full sun	moist well drained	June, July
		Pisum sativum	Sugar Snap Peas	4-6	.5	full sun	medium	June, July, Aug, Sept
		Solanum lycopersicum	Tomato	6-8	1.5-3	full sun	wet well drained	June, July, Aug, Sept, Oct
		Cucumis sativus	Cucumbers	1-1.5	12	full sun	wet well drained	June, July, Aug, Sept, Oct
		Solanum melongena	Eggplant	1-4	1-2	full sun	moist well drained	June, July, Aug, Sept, Oct
		Cucurbita pepo	Zucchini	2-3	3-4	full sun	moist well drained	June, July, Aug, Sept, Oct
		Perovskia atriplicifolia	Azure Sage	3-5	2-3	full sun o partial shade	medium	July, Aug, Sept, Oct
		Curcurbita maxima	Pumpkin	1-2	10-20	full sun	medium	Aug, Sept, Oct

resources: UI Extension Office, theessentialgardenguide.com, www.bhg.com,daytonnursery.com

FIGURE 42. PAGE 10. *Trisha Hurst 2016*

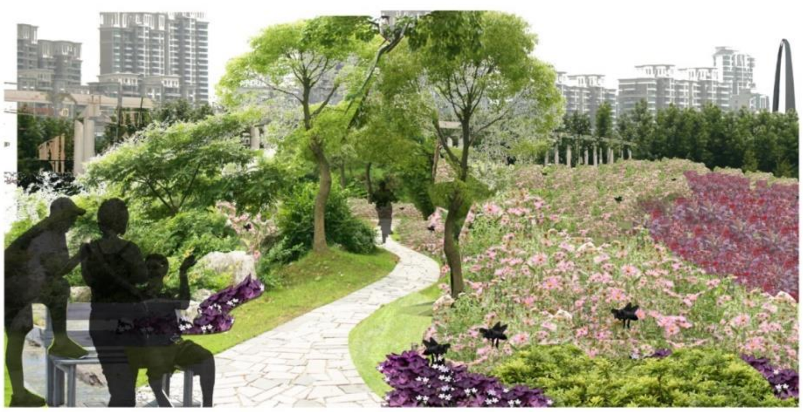
Ornamental Pesticide use is one of the greatest hazards to urban and suburban honey bee populations.

Pesticide Alternatives

Proactive planning and care are the best alternatives. Healthy plants are less likely to become diseased or infested.
Begin with the least toxic and give time to work. When an issue arises, start with the least toxic element, knowing that some natural remedies are working on the foundational problem not just the resulting damage so they are often not quick fixes.
General Use:
Fatty-acid soap and water
Boric Acid
Diatomaceous earth and silica aerogels
Botanical pesticides
Neem oil

Links for addressing specific pests:
http//www.pesticide.org/factsheets.html
http://www.beyondpesticides.org/alternatives/factsheets/index.htm

FIGURE 43. BACK COVER. *Trisha Hurst 2016*



For questions, suggestions or comments on the brochure please contact
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